SILURIAN FOSSILS FROM OHIO, WITH NOTES ON RELATED SPECIES FROM OTHER HORIZONS.

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The term West Union Cliff was proposed by Prof. Edward Orton in the Report of Progress in 1870, published by the Geological Survey of Ohio in 1871. On page 274 of this report he states that this formation "can be studied to excellent advantage in the typical section of Bisher's dam, where it forms the first line of cliffs in ascending the hill. At this point, it measures 45 feet. To the southward, it is reinforced. It is Dr. Locke's 'Cliff limestone,' of Adams county—to which he assigns a thickness of 89 feet at West Union." It should be noted that although the name of the formation is chosen from West Union, that no description of the West Union section is given; Bisher's dam is regarded as offering the typical section, but no detailed description of the Bisher's dam section is given, beyond the general statement that near Hillsboro it consists of a yellowish, impure magnesian limestone, and that the stone is rather massive than even-bedded in its appearance. Bisher's dam is about a mile south of Hillsboro.

The overlying rock, or Upper Cliff, was called by Orton the Blue Cliff. The best exposures of the Blue Cliff are stated to be at Hillsboro, along the abandoned line of the Cincinnati and Hillsboro railroad, at Academy Hill and at the Trimble quarry at the eastern end of the railroad cut at the eastern margin of the city of Hillsboro. The prevailing color is blue, weathering into various shades of drab and buff. The thickness of the Blue Cliff proper is from 20 to 30 feet; it is underlaid by 5 to 15 feet of blue shale or soapstone, producing a maximum thickness of 30 plus 15, or 45 feet. The basal part of the Blue Cliff proper generally consists of quite massive limestone courses, often more or less crinoidal. The Blue Cliff was incorrectly identified by Prof. Orton with the Springfield dolomite of the more northern counties of Ohio.

Those Niagaran limestones which lie above the Blue Cliff in the Highland county areas, especially at Hillsboro, were correlated by Prof. Orton with the Guelph of New York and

Ontario and the Cedarville dolomite of the more northern counties in Ohio.

The fossils cited by Prof. Orton from the Lower or West Union Cliff are found in a limestone layer occurring from 8 to 10 feet above the base of the formation. This is a continuous and very fossiliferous horizon throughout Highland and Adams counties, in Ohio, and occurs as far south as Martins, in Lewis county, in Kentucky. In the Fauna of the Bisher member of the West Union formation, listed on a following page, all of the fossils cited from Hillsboro, Danville, Sinking Springs, Crooked Creek, Peebles, West Union and Martins came from this horizon, while the remainder came from approximately the same zone. Fossils from the James Sanderson locality are here listed as from Danville.

Among the fossils cited by Prof. Orton from the Upper or Blue Cliff are *Halysites*, *Favosites* and Zaphrentid corals identified by him as *Streptelasma*. The spherical concretions stated to be common in Marshal township, in Highland county, unquestionably are a form of Stromatoporoid.

The rock identified as Guelph or Cedarville contains in the Hillsboro area a considerable abundance of *Pentamerus oblongus*. *Megalomus canadensis*, *Trimerella acuminata*, *Trimerella grandis*, and *Trimerella ohioensis* are listed by Prof. Orton from this rock. In the Hillsboro area, according to Prof. Orton, *Megalomus canadensis* and *Pentamerus oblongus* occur more or less associated, although in very unequal numbers. Farther eastward and southward, however, in Ohio, *Megalomus* and *Trimerella* occur in strata *above* the *Pentamerus* containing layers, whenever the latter occur, which is rarely the case.

While the various observations of Prof. Orton on the faunas of the Lower Cliff, Blue Cliff, and Guelph formations of Highland county and of the neighboring Adams county are confirmed by later investigations, they are not sufficiently detailed to serve to correlate the southern Ohio strata here mentioned with those occurring elsewhere. To supply the necessity for more detailed information, at least in part, the following lists of the fossils found in the Bisher and Lilley members are provided, accompanied by a description of some of the less known forms. The Bisher member here corresponds to the Lower or West Union Cliff of Orton, while the Lilley member corresponds to the Upper or Blue Cliff.

FAUNA OF BISHER MEMBER OF WEST UNION FORMATION.

Cornulites clintoni Hall; Crooked Creek, West Union, Glen Springs.
Chasmatopora angulata (Hall); West Union.
Clathropora frondosa Hall; West Union, Glen Springs.
Pholidops subelliptica Savage; Sinking Springs.
Orthis flabellites Foerste; Port William.
Dalmanella elegantula (Dalman); Port William, Peebles, Harin Hill.
Rhipidomella hybrida (Sowerby); Port William, Hillsboro, Danville.
Rhipidomella magnicardinalis Foerste (=hybrida?); Peebles, West Union, Glen Springs.
Platystrophia daytonensis Foerste; Port William.
Platystrophia pauciplicata Foerste; West Union.
Leptaena rhomboidalis (Wilckens); Port William, Hillsboro, Danville, Crooked Creek, West Union, Martins, Harin Hill, Glen Springs.
Plectambonites transversalis (Wahlenberg); Danville.
Schuchertella confertus Foerste; Port William, Danville, Martins.
Schuchertella prosseri Foerste; Port William, Hillsboro, Danville, Peebles.
Stropheodonta (*Brachyprion*) *plana* Foerste; Port William, Danville, Sinking Springs, Crooked Creek, Peebles, West Union, Martins, Harin Hill.
Stropheodonta (*Brachyprion*) *plana* Foerste, broad variety; Danville.
Camarotoechia acinus subrhomboidea Foerste; Danville, Martins.
Camarotoechia neglecta (Hall); Peebles, West Union.
Camarotoechia pisa (Hall and Whitfield); Danville, Peebles, Martins.
Camarotoechia roadsi Foerste; Hillsboro, Crooked Creek.
Camarotoechia cf. stricklandi; Port William, Peebles.
Rhynchotreta cuneata americana (Hall); Peebles, West Union, Carrs, Glen Springs.
Atrypa reticularis elongata Foerste; Port William, Hillsboro, Danville, West Union.
Atrypa rugosa Hall; West Union, Glen Springs.
Trematospira camura pauciplicata Foerste (=Atrypa?); West Union.
Spirifer eudora Hall; West Union.
Spirifer harinensis Foerste; Harin Hill.
Spirifer nanus Foerste; West Union, Glen Springs.
Spirifer niagarensis (Conrad.) (=repertus Foerste?); Port William, Danville, Peebles, West Union, Harin Hill.
Spirifer radiatus Sowerby; Port William, Hillsboro, Danville, West Union, Martins.
Spirifer radiatus obsoletus Foerste; Glen Springs.
Cyrtia myrtia (Billings); West Union.
Whitfieldella cylindrica Hall; Port William, Hillsboro, Danville.
Whitfieldella, form from which *cylindrica* is a derivative; Peebles, West Union, Harin Hill, Glen Springs.
Diaphorostoma cliftonense Foerste; Martins.
Diaphorostoma niagarense (Hall); Port William, Hillsboro, Danville, Peebles, West Union.

Platyceras angulatum (Hall); Peebles.
Illaenus depressus Foerste; Glen Springs, Martins.
Bumastus ioxus (Hall); Danville.
Cyphaspis sp.; West Union.
Encrinurus sp.; West Union.
Calymene niagarensis Hall; Martins, Harin Hill.
Trimerus delphinocephalus Green; Sinking Springs, Crooked Creek, Peebles, West Union, Martins.
Cheirurus niagarensis (Hall); West Union.
Dalmanites limulurus brevicaudatus Foerste; Hillsboro, Danville, Sinking Springs, Crooked Creek, Peebles, West Union, Martins.

FAUNA OF LILLEY MEMBER OF WEST UNION FORMATION.

QUARRY WITHIN EASTERN LIMITS OF HILLSBORO, OHIO.

Holophragma calceoloides Lindstrom.
Zaphrentis digoniata Foerste.
Cyathophyllum roadsi Foerste.
Acervularia paveyi Foerste.
Strombodes striatus (D'Orbigny).
Plasmopora follis Edwards and Haime.
Coenites verticillatus (Winchell and Marcy).
Halysites labrynthicus (Goldfuss).
Stromatoporid.
Rhipidomella hybrida (Sowerby).
Leptaena rhomboidalis (Wilckens).
Stropheodonta (*Brachyprion*) *newsomensis* Foerste.
Anastrophia internascens Hall.
Camarotoechia indianensis (Hall).
Camarotoechia cf. neglecta (Hall).
Rhynchotreta cuneata americana Hall.
Atrypa reticularis hillsboroensis Foerste.
Spirifer crispus (Hisinger).
Poleumita paveyi Foerste.
Poleumita prosseri Foerste.
Trochonema fatuum (Hall).
Diaphorostoma hillsboroensis Foerste.
Proetus collinodosus Foerste.
Encrinurus cf. ornatus (Hall and Whitfield).
Calymene cf. vogdesi Foerste.
Dalmanites brevigladiolus Foerste.

CROOKED CREEK, NEARLY TWO MILES NORTH OF LOCUST GROVE, OHIO.

Cyathophyllum radicula Rominger.
Omphyma cf. verrucosa Rafinesque and Clifford.
Cystiphyllum niagarense Hall.
Heliolites subtubulatus (McCoy).
Favosites spinigerus Hall.
Striatopora small celled.

In case of the fauna listed from the Bisher member, all of the fossils listed from Hillsboro, Danville, Sinking Springs, Crooked Creek, Peebles, West Union and Martins came from the richly fossiliferous layer occurring about 8 to 10 feet above the base of this member. The fossils listed from Port William apparently come from about the same horizon, as far as may be judged from the fossils present. Those listed from Carr's, Harin Hill and Glen Springs at least belong to the Bisher member. The exact location of the various exposures here cited is as follows:

Half a mile west of Port William, several hundred yards south of the bridge, an exposure of the Bisher member occurs in the creek. A mile southeast of Hillsboro, several hundred yards northeast of Bisher dam bridge, typical exposures of the Bisher member occur along the hill front, and continue at various intervals as far as the deep valley southeast of the built-up part of Hillsboro. About a mile north of Danville, on the east side of the Hillsboro pike, is the James Sanderson farm exposure mentioned by Prof. Orton. Half a mile west of the southern end of Sinking Springs, the Bisher member is exposed on the western side of Baker Fork. North of Crooked Creek, a mile and a half north of Locust Grove, the Bisher member is exposed in a quarry west of the pike. Half a mile west of Peebles, along the railroad, a large quarry exposes the full thickness of this member. In the southeastern corner of West Union, on the Beasley Fork road, a small roadside quarry exposes the basal half of the Bisher member. The remainder of the section is exposed in the open fields eastward. The outcrop at Carrs is about half a mile south of the railroad station, which is about 8 miles west of Vanceburg, in Kentucky. The outcrop is formed by the cut of the road across the hill ridge. Martins is located about 2 miles southwest of the road cut. The Bisher member forms the upper part of the knob northwest of the Martin store. Harin Hill is about 4 or 5 miles southwest of Martins; the exposure is made by the road from Valley to Ribot, which cuts across the hill. Glen Springs is 4 or 5 miles south of Harin Hill, on the road from Valley to Esculapia Springs. Carrs, Martins, Harin Hill and Glen Springs are all in Lewis county, Kentucky.

In case of the fossils listed from the Lilley member, all cited from the quarry within the eastern limits of Hillsboro

occur either in the 2-foot clay shale which overlies the typical Upper or Blue Cliff rock, or in the immediately underlying parts of the Upper or Blue Cliff rock, within 5 feet of the base of the overlying clay shale. This clay shale is referred to in the accompanying pages as the *Holophragma* zone, but *Holophragma* ranges downward into the underlying Upper or Blue Cliff rock. At the exposure immediately north of Crooked creek, on the east side of the pike from Locust Grove to Sinking Springs, at highest road level, exposures occur which are regarded as stratigraphically equivalent to the top of the Upper or Blue Cliff rock, as exposed at Hillsboro.

It should be emphasized that in these lists are included only those fossils occurring in the lower part of the Bisher member and in the upper part of the Lilley member. The fauna of the intermediate strata has not been well worked out.

The Bisher member includes all of the Lower or West Union Cliff of Orton. The Lilley member includes the massive limestone layers which form the typical Upper or Blue Cliff of Orton. The intermediate blue shale or soapstone was included by Orton in the basal part of his Upper or Blue Cliff formation. In the vicinity of Hillsboro it is practically unfossiliferous. Such few fossils as may be identified in this intermediate horizon appear to belong to the lower or Bisher fauna rather than to the upper or Lilley fauna. The highest strata exposed in the southeastern part of West Union may correspond to these upper more shaly members. Such fossils as they contain appear more nearly related to the Bisher fauna than to the Lilley fauna. For the present, therefore, the base of the Lilley member in the Hillsboro section, is drawn at the base of the bluish, apparently argillaceous limestone which lies immediately beneath the clay shale containing *Holophragma calceoloides* in abundance. At the Zink or Corporation quarry this limestone has a thickness of 14 feet, and at the Trimble quarry its thickness is nearer 21 feet. Beneath this more massive limestone occurs a thinner-bedded, more or less laminated, and frequently cherty limestone, with few fossils, beneath which occurs the blue shale or soapstone mentioned before. No trace of the characteristic Lilley fauna has been found so far in the cherty limestone layers which occur beneath the more massive, blue, apparently argillaceous limestone, and, therefore, the base of the more massive blue limestone is regarded as forming the base of the Lilley member.

No trace of the Bisher fauna has been found as yet north of Port William, at the northern margin of Clinton county, in Ohio. Much higher strata occur at Leesburg, in the northern part of Highland county, but none of the characteristic fossils of the Lilley member have been identified at this locality, so that, at present, the Lilley fauna appears of very limited geographical extent.

The faunas of the Niagaran strata of Highland and Adams counties, in southern Ohio, have little in common with those of the Niagaran strata of southern Indiana. On that account any attempt at correlation is likely to prove of little value.

The Bisher fauna contains *Spirifer niagarensis* and *Bumastus ioxus* in the same form as in the Osgood formation of southern Indiana, and the *Whitfieldella cylindrica* of the Bisher fauna is represented in the Osgood fauna of southern Indiana by a similar, though smaller form. In the Bisher exposure in the quarry along the Beasley Fork road, in the southeastern part of West Union, a single plate occurred containing the very characteristic double pairs of pores found in *Trematocystis* and other cystids incorrectly described by S. A. Miller from Indiana as *Holocystites*. These few fossils are scarcely enough to correlate the Bisher member of southern Ohio with the Osgood formation of southern Indiana; however, this is the only correlation which the present evidence seems to suggest. Immediately overlying the argillaceous strata at the base of the section on the creek east of Leesburg, in the northern part of Highland county, occur *Stephanocrinus gemmiformis* and *St. hammelli*, the second of which is characteristic of the Osgood formation in southern Indiana, but the precise correlation of the Leesburg stratum containing these specimens of *Stephanocrinus* with those exposed in the Hillsboro section is still in doubt. If they are of Bisher age, they would assist in correlating the Bisher strata with those of Osgood age.

In the fauna of the Lilley member, *Cyathophyllum radicula*, *Omphyma* cf. *verrucosa*, *Strombodes striatus*, *Cystiphyllum niagarense*, *Plasmopora follis* and *Coenites verticellatus* suggest relationship with the Louisville limestone of southern Indiana and the adjacent part of Kentucky. *Trochonema fatuum*, from the Racine of Wisconsin, is known also from the Guelph of New York and the Louisville of Kentucky. *Poleumita paveyi* and *Poleumita prosseri* are both related to Guelph species. *Dal-*

manites brevigladiolus is most nearly related to *Dalmanites platycaudatus* from the Racine of Illinois. Provisionally, the Lilley member is correlated with the Louisville member of Southern Indiana and the adjacent parts of Kentucky.

An approximate correlation of the Bisher member with Niagaran strata in New York state is made possible by the fact that the upper part of the Crab Orchard shale, which lies immediately beneath the Bisher member, contains *Liocalymene clintoni*, *Beyrichia lata*, and other fossils occurring in the middle part of the typical Clinton section of New York. In the overlying Irondequoit limestone, however, at the top of the Clinton of New York, occur numerous species found also in the Bisher member, including *Cornulites clintoni*, *Orthis flabellites*, *Spirifer radiatus*, *Rhynchotreta americana*, *Whitfieldella cylindrica*, *Anastrophia interplicata*, *Stephanocrinus gemmiformis*, *Trimerus delphinocephalus* and *Bumastus ioxus*. Provisionally, therefore, the Bisher member is correlated with the Irondequoit limestone of New York.

The coral element in the Lilley fauna suggests correlation of the Lilley member with the western extension of the Lockport dolomite, as it is seen on Manitoulin and Drummond islands, in the northern part of Lake Huron. Such fossils as *Cyathophyllum radicula*, *Omphyma verrucosa*, and *Strombodes striatus* are characteristic of this western phase of the Lockport.

If the Bisher fauna be correlated with the Osgood of Indiana and the Irondequoit of New York, and if the Lilley fauna be correlated with the Louisville of Indiana and Kentucky and with the Lockport of southern Ontario, then it is possible that a gap in time exists between the two, although this gap may be filled partially by that part of the fauna of the Bisher member which exists in its upper layers, this fauna not having been sufficiently studied so far to determine the question.

In Ohio, *Strombodes striatus* has been found also in the Springfield limestone, at the base of the excavation for the Lockington dam, four miles north of Piqua, Ohio.

The relationship of the Lilley fauna appears to be with the overlying Guelph, rather than with the underlying Bisher fauna.

It is believed that eventually it will be found that the line of separation between the Bisher and Lilley members of the Niagaran must be drawn considerably higher than the line

between the West Union Cliff and the Upper or Blue Cliff, as drawn by Orton at Hillsboro. Moreover, if Hillsboro is to be considered as the type area for the Lower Cliff of Orton, the latter oughtto receive a name taken from the Hillsboro area. Therefore, the name Bisher has been chosen. However, at any distance from the Hillsboro area, it has proved so rarely possible to discriminate the Bisher and Lilley members, if indeed the latter is present, that a collective term seems desirable. For this service the term West Union, used by Orton, has been regarded as serviceable and as much more in keeping with the exposures at West Union, Ohio, where no trace of the Lilley member can be identified.

Dinobolus conradi (Hall).

Plate XVII, Fig. 6.

A cast of the interior of the pedicel valve, found in the Cedarville dolomite, in the most eastern of the Mills quarries, southwest of Springfield, Ohio, is here figured. This species was described originally from the Leclaire limestone at Leclaire, Iowa, and from the Racine limestone at Racine, Wisconsin. It makes its appearance in Wisconsin as early as the Lower Coral beds, in the lower part of the Waukesha beds, which lie beneath the Racine limestone. In Ohio this species has been known hitherto only from the single individual, from the Niagaran at Crawford, in Wyandot county, figured by Hall and Whitfield in the second volume of the Palæontology of Ohio, in 1875. This locality lies about 70 miles north of Springfield; here it is associated with *Megalomus canadensis* and casts of *Trimerella*, suggesting an age corresponding with that of the *Megalomus* beds of Highland and Adams counties, in southern Ohio.

Schuchertella prosseri Sp. nov.

Plate XVI, Figs. 1 A-E.

At the *Whitfieldella* horizon, nine feet above the base of the Lower of Bisher member of the West Union formation, about a mile southeast of Hillsboro, Ohio, along the hill-front northeast of the Bisher dam bridge, a large species of *Schuchertella* is common. Occasional specimens occur also near Danville, and a half a mile west of Port William, Ohio. Among described species, this lower West Union species resembles most the *Schuchertella tenuis* described by Hall from the Waldron shale of Indiana.

The pedicel valves are distinctly concave, the beak being slightly elevated above the adjacent parts of the valve. The brachial valve is convex, with the greatest convexity anterior to the center of the valve. The sides of the shell converge moderately posteriorly, so that the hinge-line is shorter than the greatest width of the shell, but there is no conspicuous rounding of the postero-lateral angles. Contrasted with *Schuchertella tenuis*, the shell is much more elongate, but the amount of elongation varies considerably in different individuals. While in the more moderately elongated shells the anterior outline may be broadly and regularly convex, in the more strongly elongated shells the convexity of the anterior outline increases toward the median line, producing sometimes a subtriangular appearance. Associated with this subtriangular appearance the concavity of the pedicel valve is most pronounced along the median line, and there is a corresponding accentuation of the convexity of the brachial valve, especially anteriorly. In the most elongated specimen at hand the greatest width of the shell was near the hinge-line, and equalled 50 millimeters; at mid-length, the width equalled 46 millimeters; ten millimeters from the front the width equalled 34 millimeters; the entire length of the shell was 50 millimeters. By comparing these dimensions with those indicated by Figures 1A and 1B on the accompanying plate, the amount of divergence of this outline from the normal type may be noted. It is in these more elongate shells that the concavity of the pedicel valve is most pronounced reaching in one case 6 millimeters. The greatest convexity noted so far is that shown by the specimen represented by Figures 1A and 1C, on Plate XVI; in this case it equals 16 millimeters, while in other specimens of equal length the convexity may not exceed 9 millimeters. The radiating striæ tend to be subequal in size, excepting of course at their point of insertion. They vary in number from 7 to 10 in a width of 5 millimeters.

The interior of the pedicel valve is exposed frequently, but the clearest indications of the outlines of the muscular area are presented by the casts presented by the matrix filling these interiors. In outline this muscular area is almost circular and is distinctly delimited except near the median line anteriorly. Posterior to the center of this muscular area there is a small oblong space locating the position of the posterior adductors. A median line of elevation, often bordered laterally by shallow lines of depression, extends across this oblong space. In occasional specimens the remainder of the muscular area is marked by more or less irregularity branching radiating lines of elevation. The dental lamellæ are short and diverge at angles of about 105 degrees.

The interior of the brachial valve presents crural ridges, about 6 mm. long, diverging at an angle of about 140 degrees, and a low, broad, median elevation of about the same length. No definite muscular area can be detected.

This species is an excellent illustration of the great variation in outline, length, and general convexity which can occur in a single species. Fortunately, in the present case, numerous

specimens from the same locality and horizon are present, preventing the discrimination of these forms into separate so-called species. In the absence of abundant material the more extreme forms might appear distinct enough to be separated at least as varieties, if not as species.

Stropheodonta (Brachyprion) plana Foerste.

Plate XVI, Figs. 2 A, B.

1909. *Stropheodonta (Brachyprion) planus* Foerste, Cincinnati Soc. Nat. Hist., Jour., vol. 21, P. 22, pl. 1, figs. 13 A-C; pl. 2, figs. 11 A, B.

At the *Whitfieldella cylindrica* horizon, in the Lower or Bisher member of the West Union formation at Hillsboro and Danville, Ohio, several specimens of *Stropheodonta* occur which differ sufficiently among each other to suggest the presence of more than one species, but the material at hand does not permit of definite diagnosis. The most obvious difference is that some specimens appear shorter and broader than others, the ratio of length to width in the former specimens being as 7 to 10, in contrast with the ratio of 8 to 10 in the latter; but, apparently, specimens of intermediate length occur also. Some of the specimens are more convex than others, and in these more convex specimens the radiating striations are subequal in size, while in several of the flatter specimens the radiating striations are finer and every fourth one tends to be more prominent; however, there is considerable variation in convexity and variation in the character of the radiating striations, and such as those noted above are known to be not uncommon among the Strophomenidæ. For the present, therefore, the specimen here figured will be referred to the species already described.

Compared with other shorter forms from the same locality and horizon, it is more convex and its radiating striations are more nearly subequal in size. The shell material is exfoliated, so as to present an almost perfect cast of the interior of the pedicel valve. Postero-laterally the muscular area is clearly delimited, the sides making an angle of 80 degrees. Posteriorly, within this area, there are two oblong shallow depressions, separated by a low, sharp, narrow ridge, and the former are interpreted as the anterior adductor scars. The anterior margin of the muscular area is not distinctly delimited in this specimen. Between the postero-lateral margins of the muscular area and the adjacent parts of the hinge-area, there are numerous sharply elevated granules, characterizing the so-called ovarian spaces. (Plate XVI, fig. 2.)

In an associated brachial valve, in which the ratio of length to width is as 77 to 100, almost the entire interior of the valve is minutely gran-

ulose, the granules tending toward linear arrangement along the crests of the fine radiating lines which correspond to the grooves between the radiating striæ characterizing the exterior of the shell. From the bilobed cardinal process short thickened lines of elevation extend obliquely forward, limiting the postero-lateral outlines of the muscular area. A short, low, but broad line of elevation also extends from the cardinal process straight forward, dividing the muscular area.

In our present state of knowledge of the Stropheodontoid shells of the Clinton group of New York, it is scarcely worth while to attempt to correlate any of the West Union forms with the latter. To me, the *Leptaena obscura*, from the upper ore beds of the typical Clinton, appears to be a Schuchertella. I strongly suspect that *Stropheodonta prisca* is identical with *Leptaena orthididea*, being associated with the latter in the iron beds of the typical Clinton. Both belong to the subgenus *Brachyprion*. *Leptaena corrugata*, another Stropheodontoid, is said to be most abundant in the upper green shale of the Clinton and in the Pentamerus limestone member beneath. *Leptaena profunda*, another Stropheodontoid, was described from the Irondequoit limestone. From among these species, the West Union specimens appear most nearly related to *Stropheodonta orthididea*.

Stropheodonta (Brachyprion) newsomensis Foerste.
Plate XVIII, Figs. 1 A-C.

In the *Holophragma* zone, at the top of the Upper or Lilley member of the West Union formation, in the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio, a form of *Brachyprion*, here figured, is not uncommon. It belongs to the more elongated forms of this genus.

Ratio of length to width 82-85 per cent. About 7 or 8 striæ occupy a width of 2 millimeters. The muscular area of the pedicel valve is bounded laterally by diagonal extensions of the dental lamellæ. There is a median septal ridge terminating posteriorly in a small, triangular callosity, with two of its angles directed diagonally toward the front. Near the foramen, the lower part of the hinge area is vertically striated, and beyond the striated area the interior of the shell, beneath the hinge area, is thickened by a linear callous growth. The cardinal process of the brachial valve consists of two lobes, grooved along the top, forming approximately a right angle with each other. From the base of these lobes two low, broad callosities, bordering the sides of the posterior part of the muscular area of this valve, can be traced diagonally forward for a distance of three or four millimeters. From the bases of the same

lobes of the cardinal process, two additional very low callosities converge toward the front so as to meet within four millimeters from the hinge line. Two low diagonal lines separate the posterior part of the muscular area from the anterior parts, and a low median line often may be noted in the intermediate area. In both valves, the interiors are finely granulated. The granules of the brachial valve appear somewhat coarser, especially posteriorly, on each side of the muscular area. In both valves the granules tend to be arranged along the crests of the lines which evidently correspond to the grooves between the striæ appearing on the exterior of the shells.

No interiors of typical *Brachyprion newsomensis*, from the Waldron of Tennessee, are at hand for direct comparison. The exteriors appear similar. (Bull. Sci. Lab. Denison Univ., 14, 1909, p. 87, pl. 4, fig. 67.)

Camarotoechia indianensis (Hall).

Plate XVII, Figs. 4 A-C.

1863. *Rhynchonella indianensis* Hall, Trans. Albany Inst., vol. 4, p. 215.

This familiar Waldron species is characterized by the presence of a low fold supporting four plications, and a shallow sinus containing three plications. All of the plications tend to be low and rounded, but are distinct as far as the beak. The general form is rhomboid-ovate. At the anterior margin of the shell the slope of the sinus meets that of the fold at a right angle, producing an oblong outline on lateral view.

Shells having the same general characteristics occur in the *Holophragma* zone at the top of the upper or Lilley member of the West Union formation, at the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio.

Camarotoechia cf. **neglecta** (Hall).

Plate XVII, Figs. 5 A-C.

The type of *Camarotoechia neglecta* is a Clinton form, from the Reynale's limestone of New York. With this Clinton form it is customary to identify certain Niagran forms which may eventually prove to belong to a distinct species.

The Niagaran forms differ from *Camarotoechia indianensis* in their smaller size, higher fold and deeper sinus, distinctly more angular plications, and a somewhat more triangular form. Frequently the depressed area within the sinus meets the area on the fold of the opposite valve at an angle which is more acute than a right angle.

At the *Holophragma* zone, in the eastern part of Hillsboro, Ohio, occasional specimens of *Camarotoechia* are found which resemble *Camarotoechia neglecta* in their more angular plication,

their higher fold and deeper sinus. They may, however, be merely variations of the species identified above from the same locality as *Camarotoechia indianensis.*

Rhynchotreta cuneata americana Hall.
Plate XVI, Figs. 3 A, B; Plate XVII, Fig. 3.

In typical *Rhynchotreta americana,* from the Waldron shales of Indiana, the two median plications on the fold of the brachial valve are wider and more conspicuously elevated than the two lateral plications on this fold; moreover, the anterior part of the shell is widened laterally so strongly that the postero-lateral outline becomes distinctly concave in mature individuals.

At the *Whitfieldella* horizon, nine feet above the base of the Lower or Bisher member of the West Union formation, in the eastern part of Hillsboro, Ohio, the two lateral plications on the median fold of *Rhynchotreta cuneata americana* (Plate XVI, Figs. 3, A, B), are only moderately below the two median plications on this fold and all four plications are of about the same width; moreover, the rate of widening of the shell anteriorly is more even, so that the postero-lateral margins are nearly straight. However, in specimens obtained from about the same horizon, at West Union, Ohio, the two median plications on the fold of the brachial valve are conspicuously elevated above the two lateral plications on this fold, as in typical *Rhynchotreta cuneata americana,* so that it does not seem possible to distinguish the forms from the Lower part of the West Union formation from the typical forms in the Waldron shale unless it be assumed that two forms are present in the West Union bed, an assumption which appears premature in our present meager information regarding the range of variation among the specimens occurring in the West Union formation.

Rhynchotreta cuneata americana is abundant at some localities in the upper part of the West Union formation, associated with numerous specimens of a small-celled species of *Favosites.* The specimen here figured (Plate XVII, Fig. 3), was obtained in the upper part of the exposures in the road-cut, south of Carr's station, in Lewis county, Kentucky. It presents a cast of the interior of the brachial valve, with its median septum, also a cast of the deltidial cavity.

Atrypa reticularis elongata, var. nov.
Plate XVI, Figs. 4 A-C.

In his report on Greene County, in the second volume of the Geology of Ohio, published in 1874, on page 671, Prof. Edward Orton stated regarding the West Union Cliff rock: "It is to be identified principally by its containing a fossil

known as an elongated form of *Atrypa reticularis*. On the ground of its occurrence in Ohio strata, a distinct designation ought certainly to be given to this form, for it is never found above the horizon of the West Union cliff." Although in my opinion the West Union formation does not occur in Greene county, and the rock thus identified there should be referred to the Euphemia dolomite, there is an *Atrypa* of an elongate form which may be regarded as characteristic of the West Union formation. This *Atrypa* is most abundant in the *Whitfieldella cylindrica* zone, nine feet above the base of the Lower or Bisher member of the West Union formation, in the southeastern part of Hillsboro, Ohio, but specimens occur also in the vicinity of Danville and of Port William, at the same horizon. In general form this variety resembles most closely the specimen figured by Hall and Clarke (Pal. New York, vol. 8, pt. 2, 1894, pl. 55, figs. 3, 4) from the shaly limestone of the Lower Helderberg group, near Clarksville, New York.

The amount of elongation of the elongate variety of Atrypa which occurs in the Bisher member varies greatly in different specimens, but is always seen best when the specimen is viewed from the same side as the pedicel valve. In full-grown specimens the beak of the pedicel valve rises rather strongly above the beak of the brachial valve. Both valves are strongly convex. The anterior part of the pedicel valve tends to be slightly flattened and that of the brachial valve to be slightly elevated so that the anterior margin of the shell is slightly nasute. The radiating plications are more narrow than in *Atrypa reticularis newsomensis*, from the Waldron shale of Tennessee, Kentucky and Indiana.

Atrypa reticularis hillsboroensis, Var. nov.

Plate XVII, Figs. 1 A-D.

In the *Holophragma* zone, at the top of the upper or Lilley member of the West Union formation, in the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio, there is a small form of *Atrypa*. This variety resembles most closely the variety *Atrypa reticularis newsomensis*, from the Waldron clay member of the Niagaran. It differs chiefly in its smaller size and in the more crowded condition of the plications.

Rarely exceeding 17 mm. in length. Anteriorly the pedicel valve tends to be marked by a distinct sinus, while the corresponding part of the brachial valve is elevated into a fold. Frequently the line of junction between the two valves, when viewed directly from in front, is strongly sinuate. Most of the specimens show concentric lines of

growth, some of which tend to become conspicuous, although on some of the specimens the lines of growth are inconspicuous over the middle and posterior parts of the shell. About 6 plications occupy a width of 5 millimeters.

Spirifer niagarensis (Conrad).

Plate XVI, Figs. 7 A, B.

Spirifer niagarensis Hall, Pal. New York, 1852, pl. 54, figs. 5 a-t.
Spirifer repertus Foerste, Cincinnati Soc. Nat. Hist. Jour., vol. 21, 1909, p. 16, pl. 1, figs. 14 A, B; pl. 2, fig. 5.

Spirifer repertus was described from the lower part of the West Union formation, at Harin Hill, about eight miles southwest of Vanceburg, in Lewis county, Kentucky. Larger specimens of apparently the same species, obtained from the *Whitfieldella* horizon, in the Lower or Bisher member of the West Union formation, about nine feet above the base of the latter, do not appear to differ from typical specimens of *Spirifer niagarensis*, as found in the Rochester shale of New York. In Indiana, this species occurs in the Osgood formation.

Whitfieldella cylindrica (Hall).

Plate XVI, Figs. 6 A-C.

1852. *Atrypa cylindrica* Hall, Pal. New York, vol. 2, p. 76, pl. 24, figs. 2 a-h.
1873. *Meristella* (?*Meristina*) *cylindrica* Meek, Pal. Ohio, vol. 1, p. 180, pl. 15, figs. 2 a-d.
1893. *Whitfieldella cylindrica* Hall and Clarke, vol. 8, pt. 2, p. 60, pl. 40, figs. 16-22.

Whitfieldella cylindrica was described from the Irondequoit limestone which forms an upper member of the Clinton formation of New York. About nine feet above the base of the Lower or Bisher member of the West Union formation, in the vicinity of Hillsboro and Danville, Ohio, a form occurs which evidently is closely related, but which attains a larger size, frequently equalling 35 millimeters.

Specimens from the West Union formation which are no larger than those from the Irondequoit limestone agree with the latter in general appearance, but specimens which are larger than the latter tend to be more distinctly flattened along the anterior half of the pedicel valve. In specimens from both horizons there is a tendency toward a narrow median line of depression along the anterior half or two-thirds of this valve. Corresponding to the broad flattening of the pedicel valve there is a broad, but slight increase in convexity of the median parts of the brachial valve anteriorly in many of the specimens from the West Union formation. Some of the specimens from the Hillsboro and Danville areas are strongly flattened laterally, especially posteriorly, this flattening attracts most attention when the shell is

viewed from the pedicel valve side of the shell. These laterally flattened shells evidently are only individual variations from the much more abundant shells in which the lateral outline is more ovate. In occasional specimens the lateral boundaries of the flattened anterior areas of the pedicel valve are slightly elevated and are bounded on their inner sides by very shallow lines of depression. In such cases, if the median line of depression be present, the anterior half of this valve appears marked by four, rather faint, low plications, somewhat as illustrated by Hall and Clarke.

The laterally compressed individuals, such as those illustrated by Meek and by Hall and Clarke, are most abundant in the vicinity of Hillsboro and Danville, Ohio, where they form only a moderate percentage of the more normal broader forms. Half a mile west of Port William, Ohio, on the road to Lumberton, a quarter of a mile south of the bridge, many of the specimens are rather broadly ovate, but a few of the laterally compressed forms occur also. The species is widely distributed in the lower part of the West Union formation in southern Ohio, but usually without any evidence of lateral compression, which seems to be a local feature.

Specimens closely resembling typical *Whitfieldella cylindrica* from the Irondequoit limestone of New York, both in size and form, occur also in the Osgood formation of Indiana, especially in the area southwest of Versailles, in Ripley county. Here also the narrower specimens are exceptional and are associated with broader, ovate forms, the latter occurring in much larger numbers.

Poleumita prosseri Sp. nov.

Plate XVII, Figs. 8 A-C.

Spire depressed, with the apex rising but slightly above the margin of the outer whorl. Whorls five or six; convexity of upper side of body whorl slightly depressed; convexity of lower side broader and distinctly flattened; umbilicus relatively small and shallow. On the upper side of the body whorl, half way between the suture and the periphery, there is a distinct but low revolving ridge. Along the periphery there is a similar, but much fainter revolving ridge. Between the two ridges just described occur two more, so as to form a series following each other at shorter intervals in a downward direction. Sometimes a fifth revolving ridge may be faintly recognized just below the peripheral line. At the ridges, the transverse striæ bend slightly backward and at the same time rise in prominence, thus producing the appearance of a revolving ridge. Six or seven transverse striæ occur in a length of 2 millimeters. The largest specimen discovered so far was 28 mm. in diameter, and had a body whorl 9 mm. in height; the thickness of the shell at the aperture equalled one millimeter.

LOCALITY AND POSITION: In the *Holophragma* zone of the upper or Lilley member at the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio. Named in honor of Prof. Charles S. Prosser, who made a special study of the Hillsboro section.

REMARKS: In general appearance this species most nearly resembles *Poleumita crenulata* (Whiteaves), from the Guelph of Canada and New York. It differs greatly, however, in its much more depressed spire. Compared with such species as *Poleumita durhamensis* (Whiteaves), the revolving ridges are much less prominent.

Poleumita paveyi Sp. nov.
Plate XVII, Figs. 9 A-C.

Spire low, but with the apex rising distinctly above the level of the outer whorl; in the largest specimen at hand, about 22 mm. in diameter, the apex of the spire rises at least 4 mm. above the outer whorl. Whorls five or six; the convexity of the outer or body whorl is more or less obliquely depressed; the convexity of the lower side of the body whorl is moderate; and the umbilicus is relatively shallow. Between the upper suture of the body whorl and its periphery there are 11 or 12 rather strong revolving ridges, equally spaced. Below the peripheral line there are about 6 additional revolving ridges, the inner of which bounds the comparatively smooth umbilicus. In the larger specimen, here described, the revolving ridges are slightly less than half a millimeter in width and are slightly more than half a millimeter apart. The revolving ridges are crossed by conspicuous transverse striæ, of which 5 or 6 occur in a length of two millimeters, toward the aperture of the body whorl. Where the transverse striæ cross the revolving ridges they are bent conspicuously backward.

LOCALITY AND POSITION: In the *Holophragma* zone, at the top of the upper or Lilley member of the West Union formation, at the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio. Named in honor of Henry Pavey, who was much interested in the geology of the area surrounding Hillsboro.

REMARKS: Compared with *Poleumita scamnata* Clarke and Ruedemann, from the Guelph of New York, both the revolving ridges and the transverse striae are coarser. In *Poleumita huntingtonensis* Kindle and Breger the spire is much higher and there is nothing known of the transverse striae. In *Poleumita plana* Kindle and Breger the revolving ridges are less numerous, are more widely spaced and the top of the spire is more flattened, being actually depressed in some specimens.

Trochonema fatuum (Hall).

Plate XVII, Figs. 7 A, B.

1868. 20th Rep. New York State Cab. Nat. Hist., p. 345, pl. 15, figs. 7, 8.

An unknown species of *Trochonema* occurs in the *Holophragma* zone, at the top of the upper or Lilley member of the West Union formation, at the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio. The general resemblance of the Hillsboro specimens to *Trochonema fatuum*, from the Racine of Wisconsin, is considerable, although in size they are much smaller. They agree in the following features:

Characterized by the broadly concave peripheral area extending longitudinally along the whorls, bounded above and below by an acute and fairly prominent ridge. From the upper ridge to the upper suture of the whorl the slope is gently concave. From the lower ridge toward the umbilicus the curvature is rather evenly convex.

Diaphorostoma hillsboroensis Sp. nov.

Plate XVII, Figs. 10 A-D.

The inner margin of the aperture apparently is thin, as in *Diaphorostoma*. Species small, none of the specimens exceeding 16 mm. in diameter. Whorls about four; the apex of the shell rising but moderately above the outer whorl. The chief characteristic feature consists in the presence of low revolving lines, which vary from 6 in a distance of 2 mm. to 9 or 10 in the same distance. These revolving lines often are not conspicuous and are readily overlooked.

LOCALITY AND POSITION: In the *Holophragma* zone, at the top of the upper or Lilley member of the West Union formation, within the eastern limits of Hillsboro, Ohio.

Platyceras angulatum (Hall).

Plate XVII, Figs. 2 A, B.

For somewhat more than one volution the whorls at the apex of the shell are in contact with each other; then they become free for a distance of at least one volution. There is a slight tendency toward longitudinal ribbing, one rib being peripheral in location, a second being basal, and a third following the inner margin of the last whorl, where the umbilicus would be in a closely coiled shell.

The specimen here figured was found in the Cedarville dolomite in the quarry at Cedarville, Ohio.

Bumastus cf. **ioxus** (Hall).

Plate XVI, Fig. 5.

Illaenus ioxus Hall, 20th Rept. New York State Cab. Nat. Hist., 1868, p. 378, plate 22, figs. 4-11, plate 23, fig. 1.
Illaenus ioxus Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 222, pl. 18, figs. 1-3.
Bumastus ioxus Raymond, Bull. Mus. Comp. Zool. Harvard Coll., vol. 60, no. 1, 1916, p. 20.

Bumastus ioxus was described from the Racine dolomite; it is known to occur both at Joliet, Illinois and at Racine, Wisconsin.

At the *Whitfieldella cylindrica* horizon, nine feet above the base of the Lower or Bisher member of the West Union formation, at the exposures along the hill-front northeast of the Bisher dam bridge, about a mile southeast of Hillsboro, Ohio, a large cranidium of *Bumastus* was found, which evidently is closely similar to that of *Bumastus ioxus*.

In this specimen from the West Union formation the palpebral lobes are relatively smaller and the distance from these lobes to the anterior margin of the cephalon is relatively greater. The facial suture intersects this margin where the latter has not curved as strongly backward as in typical *Bumastus ioxus*. Dorsal furrows faint, broad, and shallow, confined to the area opposite the palpebral lobes. The convexity of the cranidium is only moderate.

Closely similar large cranidia occur in the Osgood limestone, in the vicinity of Osgood and elsewhere in Ripley county, Indiana.

Proetus undulostriatus Hall.

Plate XIX, Figs. 6, 12.

The type of *Proetus undulostriatus* was refigured by Ruedemann in Bulletin 162 of the New York State Museum, in 1912. In this figure (Loc. cit., pl. 9, fig. 2) only the right posterior lobe appears to be differentiated on the glabella. In a second specimen figured in the same bulletin from the same locality and horizon (Loc. cit., pl. 9, fig. 3) three pairs of glabellar furrows are indicated. Of this second specimen Dr. Ruedemann prepared for me an outline drawing (Pl. XIX, Fig. 12) accompanied by the description given below. In view of the great difficulty of distinguishing species of *Proetus* from different Ordovician horizons, these notes by Dr. Ruedemann will prove very useful. Both specimens of *Proetus undulostriatus*

were found in the Snake Hill beds in the basal Trenton, at Snake Hill, New York.

"The marginal border and interspace are as represented (in figure 3 on plate 9 of bulletin 162), or rather the interspace is still a little wider than shown in the figure. The glabellar furrows are as faint as represented, only the last lobe stands out a little more distinctly, similarly as in Beecher's figures (Amer. Geol., vol. 16, 1895, p. 173, pl. 9, figs. 5-7). I had still another cephalon of the *Proetus* from the Canajoharie shale, which showed very distinctly set off basal lobes. I have never seen a pygidium of *Proetus undulostriatus*. In the '*Cyphaspis hudsonica*' (Bull. 49, 1901, pl. 4, figs. 8, 9; see also plate XIX, fig 6 in the present paper) the space between the marginal border and the glabella is as represented, the marginal border, however, is broken at the top and the draftsman has represented its width as seen in the broken part. I have no doubt that it is wider than drawn, about as wide as the interspace to the glabella, as shown by the camera outline (here reproduced as Fig. 6 on Plate XIX). There is no depression lining the inner side of the border, nor was it intended to show one, as may be seen from the accompanying profile drawing (Fig. 9 on plate 4, of Bull. 49)."

The specimens of *Proetus* figured by Beecher (Loc. cit., pl. 9, figs. 5-7) from the Utica shales, at Rome, New York, evidently had distinctly defined basal lobes on the glabella and in this respect resemble *Proetus undulostriatus* rather than typical *Proetus parviusculus*. If the segmentation of the pleural ribs on the pygidium is indicated correctly, there are apparently six ribs on each side, occupying all of the space as far back as the end of the axial lobe. Assuming that the ribs are grooved medially, the pygidium still differs from that of typical *Proetus parviusculus*.

Proetus parviusculus, Hall.

Plate XIX, Figs. 11 A, B.

1872. Twenty-fourth Rept. New York State Cab. Nat. Hist., pl. 8, fig. 14.

Proetus parviusculus is cited by Bassler, in his Bibligraphic Index of American Ordovician and Silurian fossils, from the Corryville member of the Maysville formation at Cincinnati, Ohio (Pl. XIX, Figs. 11, A, B.), and a typical specimen from that horizon is figured here.

It closely resembles *Proetus undulostriatus* Hall, from the glabella presents essentially the same outline, narrowing toward the front, with the sides slightly concave at the anterior end of the eyes. Assuming that typical forms of *Proetus undulostriatus* are characterized by the presence of more or less distinct posterior glabellar furrows, *Proetus*

parviusculus possibly may be distinguished by the entire absence or at least considerable indistinctness of these furrows. In *Proetus parviusculus* the basal lobes may be indistinctly indicated by a slight depression of the glabella there where the furrow limiting these lobes might be expected, but usually this depression is too indistinct to attract attention even on careful search.

The indistinctness of the basal lobes of *Proetus parviusculus*, found in the type specimen of this species, is not confined to specimens of *Proetus* occurring in the Maysville formation, but occurs also in forms found in much lower strata.

A cranidium found in the railroad cut north of Cynthiana, Kentucky, in strata referred to the Cynthiana formation, can not be distinguished from *Proetus parviusculus*.

Another cranidium (Plate XIX, Figs 10, A, B), found in the upper part of the Benson member of the Trenton formation, directly beneath the Brannon member, northwest of Bridgeport, Kentucky, associated with *Strophomena vicina* Foerste, also bears a close resemblance to *Proetus parviusculus*, but the glabella is a little flatter, and there are very faint traces of glabellar furrows, too faint, however, to suggest *Proetus undulostriatus*, if the presence of distinct glabellar furrows be regarded as an essential characteristic of that species.

Apparently those specimens of *Proetus* having distinct basal glabellar lobes are more common in the Ordovician strata of the New York basin, and those with indistinct basal glabellar lobes are more common in the Ordovician areas surrounding Cincinnati, without regard to separation of these strata into Cincinnatian and Trenton formations.

A pygidium of *Proetus* was found half way between Flag run and Emily run, about 4 miles west of Drennan Springs, in Henry county, Kentucky. Here it occurred in that part of the Cynthiana formation to which Ulrich applied the term Gratz. A pygidium was found within five feet above the level of the railroad at the exposure south of DeMossville, on the northern edge of Pendleton county, in strata also referred to the Cynthiana formation. Another pygidium occurred in the Cynthiana formation north of Rogers Gap, Kentucky. The pygidium from the locality west of Drennan Springs possesses the following characteristics:

The axis of the pygidium is prominent, and is crossed by three distinct rings and also by three rings becoming successively much less distinct, leaving at the posterior termination of the axis a space equal in length

to that of one or two of the posterior rings. The pleural lobes are marked by three distinct ribs and a fourth, much less distinct rib, leaving an unoccupied space at the posterior end of the axial lobe sufficient for the insertion of a fifth rib, which, however, does not occur. The pleural lobes are convex, excepting toward the margin, where, for a space about as wide as the distance from the termination of the axial lobe from the posterior margin of the pygidium, the curvature is distinctly concave along the entire margin.

Proetus determinatus, Foerste.

Plate XIX, Figs. 14 A-D.

1887. Foerste. Bull. Sci. Lab. Denison Univ., vol. 2, p. 91, pl. 8, figs. 2, 3, 3a.
1913. Savage. Bull. Geol. Surv. Illinois, No. 23, p. 104, pl. 6, figs. 10, 11.

Proetus determinatus as identified by Savage from the gray limestone in the upper part of the Edgewood limestone, near Thebes, Illinois, differs from *Proetus princeps* chiefly in the smaller size of the occipital lobe occurring at each end of the neck ring, and in the presence of distinct furrows along the segments of the pleural lobes of the pygidium.

The lobe at each end of the neck ring evidently originated from the neck ring itself, since only a weak furrow separates it from the latter; this furrow does not actually reach the posterior margin of the neck ring, but reaches the dorsal furrow a slight distance anterior to this posterior margin; it is most distinct where it leaves the neck-furrow. A small granule ornaments the median part of the neck ring. The glabellar furrows are faintly defined or obsolete.

In both *Proetus determinatus* and *Proetus princeps*, the concave flexure limiting the posterior part of the anterior border is separated from the anterior margin of the glabella by only a short distance.

It is probable that the faintly defined or obsolete glabellar furrows are represented, on the under side of the cranidium, by much more strongly defined ridges, and that frequently the presence of the latter may be detected through the partially translucent test.

Proetus princeps, Savage.

Plate XIX, Figs. 13, A, B.

1913. Bull. Geol. Surv. Illinois, no. 23, p. 57, pl. 2, fig. 14.

The cranidium figured by Savage is characterized by the large size of the lobe occurring at each end of the neck ring. These lobes appear to have originated from the neck-ring, having been cut off from the latter by oblique furrows.

The axial lobe of the pygidium is marked by about 10 rings, rather faint near the posterior end of the lobe. The grooves along the ribs of the pleural lobes are either very faint or entirely obsolete. Usually only the three anterior pairs of ribs show traces of these grooves, if any are present.

LOCALITY AND POSITION: Girardeau limestone, near Thebes, Illinois.

Proetus collinodosus, sp. nov.

Plate XVIII, Figs. 7 A, B.

Cranidium 10 mm. in length along the middle; of this length 7 mm. is occupied by the glabella, 1.7 mm. by the anterior border, and 1.3 mm. by the neck-ring. The anterior part of the glabella is in contact with the furrow which outlines the inner margin of the anterior border of the cranidium, and, when viewed directly from above, appears to encroach slightly upon the posterior margin of this border. Posteriorly the glabella has a width of 7 mm., and its general outline is oval-triangular, the sides converging anteriorly at an angle of about 40 degrees. Along its anterior margin the glabella is relatively narrow and opposite the anterior margin of the palpebral lobes the sides of the glabella tend to be slightly concave. The palpebral lobe appears to be 3 mm. in length and, at its widest part, it diverges only 1.5 mm. from the glabellar furrow. The posterior border of the glabella is strongly defined. The neck-ring is comparatively flat for the greater part of its width, and bears a minute tubercle at its middle. Laterally, the ends of this neck-ring curve forward and are nodosely elevated, forming rather conspicuous occipital lobes. These lobes are obliquely elliptical, about one and a half millimeters in maximum width, and are distinctly delimited from the remainder of the neck-ring.

A dissociated free cheek shows the same broad marginal border, and a genal spine similar in size and form to that of other species of this genus.

A dissociated pygidium is 4.5 mm. in length and 8 mm. in width. The posterior part of the axial lobe is about one millimeter distant from the margin of the pygidium. This axial lobe is marked by 6 or 7 fairly distinct rings but there is sufficient room posteriorly to admit of a total of 8 rings. The pleural ribs are indistinctly defined, at least in the only specimen at hand.

LOCALITY AND POSITION: In the *Holophragma* zone, at the top of the upper or Lilley division of the West Union formation, in the Zink or Corporation quarry, in the eastern part of Hillsboro, Ohio.

REMARKS: From *Proetus determinatus* Foerste, from the Brassfield formation of Ohio, this species is distinguished readily by the more triangular outline of its glabella, and by the close approach of the anterior part of the glabella to the posterior part of the broad marginal border of the cranidium, only a narrow groove separating the two.

Proetus pachydermatus Barret, from the Helderbergian of New Jersey and Maryland, also has two lateral lobes belonging to the neck ring, but the marginal border of the cranidium is farther removed from the anterior outline of the glabella, and

the glabellar furrows are distinct; neither of these features is seen in *Proetus collinodosus*.

Encrinurus cf. **ornatus** Hall and Whitfield.
Plate XVIII, Figs. 2 A-C.

Only a fragment of a cranidium is known. Its length along the middle is estimated at 7 mm., and its width, to the end of the genal angles, but not including the genal spines is estimated at 22 mm. The length of the genal spines is 5 mm. Conspicuous tubercles occur on the glabella, on the more strongly convex part of the cheek which surrounds the eye, and on the marginal rim. On the depressed part of the free cheek, toward the genal angle, the tubercles are inconspicuous. In front of the series of conspicuous tubercles on the free cheeks there is a much less conspicuous series of smaller tubercles. Near the genal angles, one or two tubercles occur also on the posterior border of the free cheek and on the genal spine.

The pygidium is obovate-triangular. Its width is 14 mm., and its length, in its present state of preservation, beginning with the anterior margin of the first annulation, is 17 mm. The posterior end apparently terminated in a short spine extending only slightly beyond that part at present remaining. The length of the axial lobe is 14.5 mm.; anteriorly this lobe is crossed by two annulations, the second of which bears a median tubercle. Posterior to the second annulation the median part of the axial lobe, for about one-fourth of its width, tends to be smooth, the annulations being distinct only along the sides of the lobe. It is rarely possible to count more than 30 annulations, those at the posterior end being indistinguishable, but in remarkably well preserved specimens, in which even the terminal annulations are distinct, as many as 36 may be counted.

In the figured specimen, tubercles occur on the median parts of the axial lobe, at annulations 2, 5, 9, 14, 20, 25, 30?, and ?, the number of the annulations bearing the last two tubercles being uncertain. In a second specimen, tubercles occurred at 2, 5, 9, 14, 19, the location of the remainder being uncertain. In a third specimen, tubercles occurred at 2, 5, 9, 13, 18, 22, 26?, and ?, the location of the last two being uncertain. In a fourth specimen, tubercles occurred at 2, 6, 9, 13, 18, 24, 29, and 33, the axial lobe terminating with the thirty-sixth annulation. That the location of even the first four tubercles may vary is shown by a fifth specimen, in which they occurred at 2, 4, 7, 12, 16, 21, and ?, the location of the last being uncertain. These observations indicate to what an extent the exact location of the tubercles along the median line of the axial lobe varies, and of how little value their location is in the discrimination of species. In general, it may be stated that seven tubercles may be counted frequently along the axial lobe of the species here described, and that an eighth tubercle may be recognized on the better preserved specimens.

There are eight pairs of pleural ribs. The distal parts of these ribs, about 4 or 5 mm. from their ends, curve strongly downward and

backward, and appear more or less parallel to the sides of the axial lobe, when viewed from above. In consequence, the posterior ribs have a slightly converging appearance posteriorly, and lie close to the axial lobe. At their distal ends the pleural ribs are lengthened parallel to the margin of the pygidium into a form slightly resembling the foot of a flattened stocking. In consequence, the margin of the pygidium is marked by 7 crenulations; the last pair of ribs does not reach the margin but terminates at a nearly obsolete point a little over a millimeter beyond the end of the axial lobe. When viewed from the lower side of the pygidium it is seen that the margin of the pygidium is abruptly infolded for a distance of about a millimeter beyond the margin of the pygidium as viewed from above. This infolded marginal part is smooth, the pleural ribs terminating at the sharp angle of infolding. The infolded part forms an angle of about 170 or 160 degrees with a horizontal plane passing through this margin. The grooves between the anterior pleural ribs are about half a millimeter in width. At the bottom of each groove there is a slight elevation, extending along its entire length. The tubercles on the pleural ribs are irregularly arranged, the location of the more prominent tubercles apparently being constant. In the accompanying figure, the more prominent tubercles have been accentuated. On the first pleural rib there is a tubercle nearly a third of its length from the axial lobe, the corresponding tubercle on the next rib being situated a little closer. On the third pleural rib the tubercle occurs nearly at mid-length. The tubercles on the fourth and fifth ribs are near the axial lobe, that on the fifth rib being slightly more distant. The tubercle on the sixth rib is a little closer than mid-length, that on the seventh rib is much closer to the axial lobe, and that on the eighth rib is only indistinctly defined near its anterior end.

LOCALITY AND POSITION: In the *Holophragma* zone, at the top of the upper or Lilley division of the West Union formation, in the Zink or Corporation quarry, within the eastern border of Hillsboro, Ohio.

REMARKS: Pygidia having the same arrangement of tubercles on the pleural ribs occur also in the Waco division of the Crab Orchard formation, at Irvine, Kentucky. The same arrangement is seen also in typical *Encrinurus ornatus*, described by Hall and Whitfield from the Cedarville dolomite at Eaton and Yellow Springs, Ohio; but the latter appears to be a larger species and the glabella is more convex. The exact arrangement of the tubercles in *Encrinurus reflexus* Raymond (Bull. Mus. Comp. Zool. Harvard, 1916, p. 25, pl. 3, figs. 7, 8), from the Niagaran at Wauwatosa, Wisconsin, is unknown, but the figure of the pygidium bears a close resemblance to known specimens of *Encrinurus ornatus*.

Calymene whittakeri Sp. nov.

Plate XIX, Figs. 9 A, B.

Anterior margin of the cephalon project in front of the glabella in the form of a lip; in the type specimen, for a distance of 3 millimeters. Compared with typical *Calymene senaria* Conrad, from the Trenton of New York, the lip is less elongate and not so nasute; the genal angles are rounded; the surface distinctly granulated, the granules being somewhat coarser than in most species of *Calymene*. The distinctive feature, however, which is regarded as most characteristic of the species, is presented by the pygidium. Here the ribs curve strongly toward the rear so as to become sub-parallel on the posterior half of the pygidium. All of the ribs extend to within a short distance of the margin of the pygidium, and the first four ribs are distinctly furrowed along their entire length. The fifth rib may be furrowed but in that case its inner margin is not limited from the median part of the pygidium posteriorly.

At Fields, about half way between Collingwood and Meaford, on the southern shore of Georgian Bay, in Ontario, the species of *Calymene* here descibed occurs in the Collingwood formation, as exposed on the shore of the bay. It is named in honor of Dr. E. J. Whittaker, of the Geological Survey of Canada, in memory of pleasant days spent together in unravelling the geology of Georgian Bay and Manitoulin island.

Calymene cf. **vogdesi** Foerste.

Plate XVIII, Fig. 6; Plate XIX, Fig. 3.

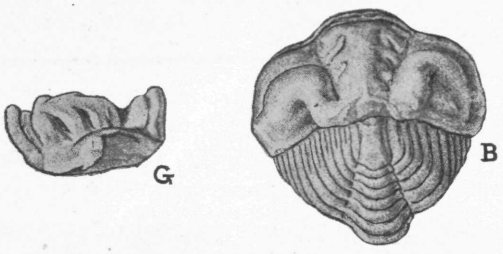
In the *Holophragma* zone, at the top of the Upper or Lilley member of the West Union formation, in the Zink or Corporation quarry, within the eastern limits of Hillsboro, Ohio, a *Calymene* is found which, among described species, most nearly resembles *Calymene vogdesi*, a typical Brassfield species.

In the specimen figured, the anterior rim of the cephalon projects 2.5 mm. beyond the anterior margin of the glabella. The anterior rim forms an angle of from 155 to 145 degrees with the general surface of the base of the cephalon. Compared with typical *Calymene vogdesi* (Plate XIX, Fig. 5), the furrow immediately anterior to the glabella is not as deep; the median part of the glabella, between the lobes, is narrower; the anterior half of the glabella, in front of the second pair of glabellar lobes, is somewhat longer and more quadratic, retaining its width as far as the groove outlining the anterior margin of the glabella. No well preserved pygidia are at hand. In typical *Calymene vogdesi* the pleural ribs extend almost as far as the margin of the pygidium; while in some specimens the ribs are faintly grooved along their entire length, in others the grooving is distinct only near the dorsal furrow and again toward the distal parts of the ribs, or the grooving may be confined practically to the proximal parts of the ribs, near the dorsal furrow.

In the *Calymene* which is so abundant in the Waldron shale in western Tennessee, here identified with *Calymene breviceps* Raymond (Plate XIX, Fig. 2), described from the Waldron shale of Indiana, the rim of the cephalon extends only for a distance of half a millimeter in front of the anterior margin of the glabella, a narrow but distinct groove intervening. Laterally, the anterior rim of the cephalon widens to about one millimeter. In *Calymene celebra* Raymond, (Plate XIX, Fig. 4), from the Niagaran of the Chicago district and from the Springfield limestone of the Eaton quarry, in Ohio, the groove between the anterior margin of the glabella and the anterior rim of the cephalon is deeper, and wider, but the anterior rim is equally narrow. In typical *Calymene niagarensis* Hall, (Plate XIX, Fig. 1), from the Rochester shale of New York, there is also a narrow furrow separating the glabella from the short anterior rim or "lip" of the cephalon.

Platycoryphe Gen. Nov.

In 1898 Pompeckj proposed the genus *Synhomalonotus* (Neues Jahrbuch Min. Geol. Pal. 1, p. 240), founded on *Calymene tristani* Brongniart.



Synhomalonotus tristani Brongniart.
B, enrolled specimen showimg glabella and inverted pygidium.
G, lateral view of glabella showing strongly raised anterior lip.
(Copied from Brongniart, Hist. Crust. Foss. 1822.)

The pygidia of this European species resemble that of *Calymene whittakeri*, figured in this paper (Plate XIX, Fig. 9 B), in the strong backward curvature of the pleural ribs. The median grooves, along the crest of the ribs, do not extend along the entire length of these ribs, but only along their more distal parts. The glabella and the anterior lip are strongly convex from side to side, and although the lateral lobes of the glabella are figured as very oblique, they are at least distinctly defined by deep grooves.

With this genotype, *Synhomalonotus tristani* Pompeckj (Loc. cit., p. 247) erroneously associated an American species, *Calymene christyi* Hall (13th Rep. New York State Cab. Nat. Hist., 1860, p. 118; 15th Rep., ibid., 1862 pl. 10, figs. 2-5), from the Waynesville member of the Richmond, in Ohio, as *Synhomalonotus christyi*. That this association is incorrect is shown by the distinctly different structure of the glabella of the latter.

In *Calymene christyi* Hall (Ottawa Naturalist, 31, 1917, Pl. 6, Fig. 29) the glabella is only moderately convex from side to side; its outline anteriorly tends to be quadratic, and the lateral furrows are relatively shallow. The anterior lip is flat, and does not curve strongly from side to side. The structure of the pygidium of this species is not well known. In the case of *Calymene platycephala* Foerste, (Pl. XIX, Fig. 16 A, B), from the Trenton of Tennessee, both the glabella and the pygidium are known, and the structure of the latter is very characteristic. Its lateral margin is deflected abruptly downward, the deflected part remaining smooth, and the pleural ribs extend only as far as the line of deflection. *Calymene dubia* Savage, (Plate XIX, Figs. 15 A, B), from the Girardeau limestone of Alexander County, Illinois, is congeneric, and another congeneric species, also in the Savage collection, occurs in the Maquoketa, near Yorkville, Illinois. For this group of species, beginning with Calymene christyi, the generic term *Platycoryphe* is proposed.

Since the pygidium of *Calymene platycephala* is better known at present than that of *Calymene christyi*, the former is chosen as the genotype of *Platycorphye*. The cranidia of all the forms here discussed are known.

Platycoryphe dubius, Savage.

Plate XIX, Figs. 15 A, B.

1913. Bull. Geol. Surv. Illinois, No. 23, p, 60, pl. 2, figs. 8, 9.

The only characteristic feature noted in the cranidium was the presence of a pit in each of the dorsal furrows, a short distance anterior to the rather faint anterior pair of glabellar furrows.

The sides of the axial lobe of the pygidium diverge at an angle of 30 degrees. The axial lobe is weakly defined, except along its posterior third, which rises distinctly above the posterior parts of the pygidium. The antero-lateral angles of the pleural lobes are obliquely and abruptly deflected downward at an angle of about 130 degrees with the adjacent part of the pygidium. This deflection is noted also in *Platycoryphe platycephalus* Foerste, from the Trenton of Clifton, Tennessee, with which the Girardeau species was compared by Savage.

In *Platycoryphe platycephalus*, (Plate XIX, Fig. 16 A, B), the lateral margin of the pygidium is abruptly deflected downward, the anterior part of the deflected margin forming an angle of about 130 degrees

with the adjacent part of the pygidium. The pleural ribs end abruptly along the line of deflection, the broadly rounded ends of the ribs projecting slightly beyond this line, the marginal part beneath being smooth. In the figured pygidium of *Platycoryphe dubius*, the marginal part of the pygidium, beneath the line of deflection, was not exposed, and hence the line of deflection was regarded, in the original description, as the lateral margin of the pygidium. However, the broadly rounded terminations of the pleural ribs, along this line of deflection, are distinctly visible. Compared with the pygidium of *Platycoryphe dubius*, the axial lobe of *Platycoryphe platycephalus* is more convex, and the furrows separating the pleural ribs are distinct as far as the line of deflection of the lateral margin.

Platycoryphe dubius is characteristic of the Girardeau limestone, in Alexander county, Illinois. Cranidia of *Platycoryphe* occur also in the Maquoketa, near Yorkville, Illinois. These resemble the cranidia of *Platycoryphe christyi*, from the Waynesville member of the Richmond of Ohio; if distinguishing features occur, the later have not been noticed. The pits in the anterior part of the dorsal furrows are small and nearly obsolete.

Ceraurinus cf. **trentonensis** Barton.

Plate XIX, Fig. 7.

Imperfect cranidium. Glabella relatively broader than in *Ceraurinus trentonensis* Barton, from the Trenton on Goat Island, in the northern part of Lake Huron; the lateral outlines of the lateral lobes are less curved; the third pair of glabellar furrows is more oblique, reaching the occipital groove at points less than the width of the third pair of glabellar lobes apart. From the Kimmswick (Prosser) limestone on Sanders Branch, in Ralls county, Missouri.

Pterygometopus confluens, sp. nov.

Plate XIX, Fig. 19.

This species differs from *Pterygometopus callicephalus*, Hall, (Pal. Minnesota Geol. Surv., Vol. III, 1897, p. 731, fig. 51), from the Trenton of New York, chiefly in the confluence of the distal parts of the first and second pairs of lateral lobes of the glabella; the postero-lateral angles of the second pair is rounded. The posterior pair of lobes is small, circular, distinctly defined from the median parts of the glabella, and is located directly beneath the rounded postero-lateral angle of the second pair of lobes. The second pair of lobes also is distinctly defined from the median part of the glabella, and a similar tendency, though much less marked, is shown also by the first pair of lobes. The posterior pair of lobes indents slightly the lateral parts of the neck segment. Between the posterior lobes, the median part of the glabella is transversely rather strongly convex, but between the first and second pairs of lobes the convexity of the median part of the glabella is moderate, and this part of the glabella is at about the same level as the adjacent lateral lobes or is only slightly below the curvature of the latter.

From *Pterygometopus intermedius*, Walcott (Pal. Minnesota Geol. Surv. vol. III, 1897, p. 728, fig. 45), from the Black River formation of Illinois, Wisconsin and Minnesota, it differs chiefly in the confluence of the distal parts of the first and second pairs of lateral lobes of the glabella. The median parts of the glabella, between these lobes, is only slightly depressed, if at all, beneath the curvature of the latter. The first pair of glabellar furrows is not convexly curved toward the front. The margin of the palpebral lobes is more strongly convex in outline, and their posterior margin almost reaches the posterior groove of the fixed cheeks.

With *Pterygometopus eboraceus*, Clarke (Pal. Minnesota Geol. Surv., Vol. III, 1897, p. 728, fig. 49), from the Trenton of New York, it agrees in the confluence of the distal parts of the first and second pairs of lateral lobes of the glabella. The cranidium of the Kentucky specimens here described, however, is relatively much shorter. This is due chiefly to the shorter length of the frontal lobe of the glabella, which is less rhombic in outline, but more transversely elliptical; the first pair of glabellar furrows is more divergent, and the anterior pair of glabellar lobes is less acutely triangular. The posterior margin of the palpebral lobes extends nearer to the posterior groove of the fixed cheeks. Glabella tuberculated; fixed cheeks smooth.

The specimen here figured was obtained from the Tyrone member of the Black River formation, at High Bridge, Kentucky. Cranidia, agreeing in every structural detail with the specimen here figured occur at the same locality, High Bridge, also at two horizons in the Campnelson member of the Stones River formation, 550 and 570 feet above sea level; these cranidia differ from those in the Tyrone member of the Black river formation only in the slightly more prominent tubercles ornamenting the glabella.

From the preceding notes it is evident that *Pterygometopus confluens* belongs to a series of closely related species characterizing the Stones River, Black River, and Trenton formations. Such a series is of little service for purposes of correlation of strata in distant exposures unless the component species are accurately discriminated.

Pterygometopus achates Billings.

Plate XIX, Fig. 8.

"In the specimen figured by Clarke the glabellar furrows were still filled with matrix; on working them out with a needle they gave the figure shown in the enclosed sketch (consisting only of the dotted part of Figure 8 on Plate XIX); the second furrow slopes distinctly backward; the third and fourth are curved, as in the photograph sent by you." (This was a photograph of *Dalmanites carleyi-rogersensis*, as

figured from the Rogers Gap member of the Cynthiana formation, in Jour. Cincinnati Soc. Nat. Hist., vol. 21, 1914, pl. 1, fig. 18; see also Fig. 18 A, on Plate XIX, accompanying the present paper). "The neck ring bears a tubercle on the middle of the posterior margin suggesting an incipient spine; this tubercle, however, is not larger than those on the front of the glabella."

An entire individual of this species was figured by Clarke in 1894 (Geol. Minnesota, vol. 3, pt. 2, p. 727, fig. 44), from the Trenton limestone at Trenton Falls, New York. At my request Dr. Rudolf Ruedemann reexamined this specimen and sent the description given above.

Those parts of Figure 8, cited above, which are not dotted, were added to indicate the relative position of the glabellar furrows on the glabella and were not included in Dr. Ruedemann's sketch. These parts may require modification, especially in connection with the neck ring.

Pterygometopus carleyi-rogersensis, Foerste.

Plate XIX, Figs. 18 A, B.

1910. *Dalmanites carleyi-rogersensis,* Foerste, Bull. Sci. Lab. Denison Univ., vol. 16, p. 85.

1914. *Dalmanites achates,* Foerste, Jour. Cincinnati Soc. Nat. Hist., vol. 21, p. 147, pl. 1, fig. 18.

So far no difference is known between the variety *rogersensis,* as found in the Rogers Gap division of the Cynthiana formation, and the typical forms of the species *carleyi,* from the Fairmount division of the Maysville formation, except in size, the Rogers Gap specimens usually being larger. In *Dalmanites carleyi* the first pair of glabellar furrows diverges at an angle of about 140 degrees, the curvature being slightly sigmoid, at first toward the front and then more lateral. The second pair of grooves curves moderately backward and sometimes terminates before actually reaching the dorsal furrows limiting the glabella laterally. The third pair of glabellar furrows curves so as to be directed slightly backward at first and then more or less forward. The corresponding parts of the neck furrow have a similar curvature. The frontal lobe of the glabella is remarkably wide and short, and has a transversely rhomboidal outline. A slightly rhomboidal appearance is characteristic of the anterior outline of the cephalon which tends to be slightly angular immediately in front of the center of the frontal lobe and also in front of the lateral part of the visual surface of the eye. The visual surface (Plate XIX, Fig. 18 B) is composed of 21 or 22 vertical rows of facets, the maximum number of facets in the middle rows being about 11 or 12. In *Dalmanites carleyi* the coarser granules are confined chiefly to the frontal lobe and to the median parts of the glabella; a few occur on the first pair of glabellar lobes, but elsewhere they usually are rare or absent.

In the variety *rogersensis*, these larger granules occur also in moderate numbers on the other glabellar lobes, on the neck ring, and less prominently, even on the fixed cheeks. This may be due chiefly to their larger size. The movable cheeks are smooth macroscopically. The exceedingly minute granules, visible only under a magnifier, covering the entire surface of the cephalon, appear more distinct in some specimens of *carleyi* than in any known specimens of *rogersensis*. In *Dalmanites carleyi* (Plate XIX, Fig. 17), a spinose granule ornaments the middle of the neck ring, close to the posterior margin. The presence of this spinose granule has not been demonstrated in any specimen of the variety *rogersensis*, but this part of the neck ring is defective in all specimens of *rogersensis* found so far.

The type of *Dalmanites carleyi-rogersensis* was obtained north of Rogers Gap, at a point 54.8 miles from Ludlow according to the mile posts along the railroad. Here it occurred in the Rogers Gap division of the Cynthiana formation. A figure of the type specimen under the name of *Dalmanites achates*, was presented in the Journal of the Cincinnati Society of Natural History, cited above, and an enlarged figure of the same specimen is provided here. (Plate XIX, Fig. 18 A).

The posterior extremity of the pygidium of *Dalmanites carleyi* is described as being curved a little upward. This feature is shown also by a specimen of this species in my possession. In a pygidium belonging to the variety *rogersensis*, found north of Rogers Gap, this upward curvature of the posterior extremity also is noted, while in another specimen referred to the same variety, but found east of Hatton, in Shelby county, Kentucky, the curvature of the posterior extremity is distinctly downward. Apparently this can not be recognized as a constant distinguishing characteristic. In the Fairmount specimens of the species *Dalmanites carleyi* the ribs on the pleural lobes of the pygidium are curved more or less backward toward their extremities, especially in case of the more posterior ribs. In the pygidia of the variety *rogersensis*, so far known, these ribs are nearly straight.

Phacops (Portlockia) mancus, sp. nov.

Plate XVIII, Fig. 3.

Anterior part of glabella apparently forming the anterior part of the cephalon; at least no trace of a border is noticed anterior to the glabella except near the lateral margin of the latter; the outline of this anterior part is semicircular. The dorsal furrows limiting the sides of the glabella are distinct, especially where limiting the anterior part of the

eye and also posterior to the middle of the palpebral lobe. Four grooves form what here is described as the anterior pair of glabellar furrows; two of these are directed transverse to the length of the cephalon and two are very oblique. The transverse pair is located slightly posterior to the mid-length of the cephalon; this pair is distinct but shallow, about a millimeter and a half in length, and terminates before reaching the dorsal furrow; it has a slightly convex curvature, directed toward the front. A short distance anterior to the lateral extremities of this pair, another pair of grooves is directed obliquely forward; this pair is much more distinct, especially where it enters the dorsal furrows; it also has a slightly convex curvature, the convex side being directed toward the median part of the glabella. The middle pair of glabellar furrows, noted in *Phacops pulchellus*, Foerste, is absent, unless this pair is represented by a slight depression anterior to the inner part of the posterior pair of glabellar furrows. The posterior pair of glabellar furrows is continuous across the median part of the glabella, but is much deeper laterally, especially for a distance slightly more than a millimeter from the dorsal furrows. This furrow is curved backward toward its extremities and that part of the glabella which lies between the transverse anterior glabellar furrows and the lateral parts of the posterior glabellar furrow presents a gently convex, more or less lobate appearance. The occipital groove also is deepest at its lateral extremities; its curvature is sufficiently like that of the posterior glabellar groove to give the intermediate part of the glabella the appearance of a narrow transverse ring. At the lateral extremities of this ring, between the deep parts of the two grooves mentioned, this ring terminates in two small, but distinctly defined circular nodules. A corresponding flexture is noted in the corresponding parts of the neck ring. The groove defining the basal part of the visual surface of the eyes rises along the posterior part of the eyes, defines the inner part of the palpebral lobes, and joins the dorsal furrows anteriorly. Between 18 and 21 vertical rows of facets occur on the visual surface, and the middle rows contain at least 10 facets, but the state of preservation in the specimens at hand is not perfect. The groove traversing the posterior part of the fixed cheeks widens and becomes shallower laterally and merges into the rather indistinct marginal groove of the cephalon. The facial suture extends from the eyes forward and then slightly above the anterior margin of the cephalon to the middle of the latter.

POSITION AND LOCALITY: The specimen figured came from the lower part of the Cedarville dolomite, in the Eastern Mills quarry, southwest of Springfield, Ohio. A second cephalon was obtained within three feet of the base of the Cedarville dolomite, in the quarry at Euphemia, Ohio.

Phacops handwerki, Weller, from the Racine beds near Lemont, Illinois, is described as lacking both the anterior and middle pairs of glabellar furrows, but in other respects the

species evidently is closely similar to the Ohio forms here described. The specimens described by Kindle from the Niagaran at Pendleton, Connor's Mill, and Georgetown, Indiana, usually lack all but the continuous posterior glabellar furrow, although sometimes also the anterior and middle glabellar furrows are present. Evidently all of these forms are closely related. Apparently their derivation is from some of the early species of *Pterygometopus*.

A comparison of the Cedarville specimen, described above, with *Phacops stokesii* Milne-Edwards, the type of the subgenus *Portlockia*, indicates that the Cedarville specimen belongs to the same subgenus.

Dalmanites brevigladiolus, sp. nov.

Plate XVIII, Figs. 4 A-E.

Pygidium terminating in a short but relatively very broad spine. In a pygidium whose axial lobe originally must have equalled at least 18 mm., possibly 20 mm., the width of the pygidium at the posterior end of the axial lobe equals 8 or 9 mm.; at 4 mm. from this axial lobe the width of the terminal spine has narrowed to 6 mm.; at 7 mm. it has narrowed to 4 mm.; it terminates at 9 mm. with a very blunt curvature. The axial lobe is rather low and depressed; it is crossed by 15 or 16 transverse rings of which the last three tend to be indistinct; the transverse grooves tend to be less distinctly defined along the median line. Pleural lobes with at least 6 or 7, sometimes possibly 8 ribs, all of which are marked by a median groove. In some specimens the more posterior grooves start off near the posterior margin of the rib and become median at mid-length. For a width of slightly more than a millimeter the lateral margins of the pygidium tend to be smooth, unmarked by the terminations of the pleural ribs. There is a tendency toward extremely low, practically obsolete tuberculation along the axial lobe.

In the only full sized specimen of a cranidium known the glabellar furrows are distinctly defined. The anterior margin of the cranidium has a flat, rounded, median lip-like extension, about the same size as in *Dalmanites platycaudatus*, Weller (Bull. Chicago Acad. Sci., Nat. Hist. Surv., No. 4, pt. 2, 1907, p. 272, pl. 25, figs. 3-5), with which the species evidently is closely related, differing chiefly in the shorter length of the flattened caudal spine.

POSITION AND LOCALITY: In the *Holophragma* zone, at the top of the Lilley member of the West Union formation, in the Zink or Corporation quarry, in the eastern part of Hillsboro, Ohio.

Dalmanites cf. **verrucosus** Hall.

Plate XVIII, Fig. 5.

In the Cedarville dolomite at Cedarville, Ohio, a cephalon was found which bears a close resemblance to *Dalmanites verrucosus* Hall, from the Waldron shale of Indiana. The Cedarville specimen is a cast of the interior of the test.

There is no evidence of tuberculation. The broad prolongation of the median part of the anterior border of the cephalon is a little narrower than in the Waldron species. The anterior pair of glabellar lobes is broad, so that the posterior margin of the frontal lobe is not sharply defined. Neither the second nor the third pairs of glabellar furrows reach the dorsal grooves, differing apparently in this respect from the Waldron species. Some of the associated pygidia are strongly tuberculated, but there is a possibility of the cephalon here figured being a new species.

Acrolichas Gen. nov.

Cranidia as in the European genus Amphilichas. Pygidia differing as follows: Three pairs of ribs, all with free tips; axial lobe narrowing posteriorly to an acute point which reaches the notch between the free tips of the posterior pair of ribs. Genotype: *Lichas cucullus* Meek and Worthen, from the Kimmswick limestone of Illinois and Missouri. (Geol. Surv. Illinois, 3, 1868, p. 299, Pl. I, Figs. 6, a, b, c; cranidium only.)

EXPLANATION OF PLATES.

PLATE XVI.

Fig. 1. *Schuchertella prosseri* Foerste. A, brachial valve of a very convex elongate form; B, pedicel valve of a less elongate form; C, profile of specimen A; D, profile of specimen B, joined with that of a brachial valve of ordinary convexity; E, cast of interior of pedicel valve, showing cast of muscular area. Bisher member, from the hill-front northwest of Bisher dam bridge, southeast of Hillsboro, Ohio.

Fig. 2. *Stropheodonta* (*Brachyprion*) *plana* Foerste. A, cast of interior of pedicel valve; B, profile of same. Bisher member; on James Sanderson farm, north of Danville, Ohio.

Fig. 3. *Rhynchotreta americana* Hall. A, brachial valve; B, lateral view. From the Bisher member, in the southeastern part of Hillsboro, Ohio.

Fig. 4. *Atrypa reticularis elongata* Foerste. A, pedicel valve; B, brachial side; C, lateral view. From Bisher member, in southeastern part of Hillsboro, Ohio.

Fig. 5. *Bumastus* cf. *ioxus* (Hall). Cranidium, from Bisher member, in southeastern part of Hillsboro, Ohio.

Fig. 6. *Whitfieldella cylindrica* (Hall). A, brachial side; B, lateral view. From Bisher member, on James Sanderson farm, north of Danville, Ohio.

Fig. 7. *Spirifer niagarensis* (Conrad). A, pedicel valve; B, brachial valve. From the Bisher member, on the James Sanderson farm, north of Hillsboro, Ohio.

PLATE XVII.

Fig. 1. *Atrypa reticularis hillsboroensis* Foerste. A, pedicel valve; B, brachial valve; C, anterior view, with pedicel valve on top; D, brachial valve from another specimen. From Holophragma zone in Lilley member, in Zink quarry, in eastern part of Hillsboro, Ohio.

Fig. 2. *Platyceras angulatum* (Hall). A, B, two views of the same specimen; at the tip of the complete specimen the volutions are in contact, but in the cast of the interior here figured this apical part is not preserved. The apical part separated from the cast and remained on another fragment of the containing rock. From the Cedarville dolomite, at Cedarville, Ohio.

Fig. 3. *Rhynchotreta americana* Hall. Brachial side. From the upper part of the West Union formation, south of Carrs station, in Lewis county, Kentucky.

Fig. 4. *Camarotoechia indianensis* (Hall). A, lateral view; B, pedicel valve; C, brachial valve. From the Holophragma zone in the Lilley member, at Zink quarry, in eastern Hillsboro, Ohio.

Fig. 5. *Camarotoechia* cf. *neglecta* (Hall). A, lateral view; B, pedicel valve; C, brachial valve. From Holophragma zone, in Zink quarry, in the eastern part of Hillsboro, Ohio.

Fig. 6. *Dinobolus conradi* (Hall). Pedicel valve, cast of interior. From Cedarville dolomite, at Mills quarry, southwest of Springfield, Ohio.

Fig. 7. *Trochonema fatuum* (Hall). A, natural size; B, enlarged. From the Holophragma zone, at Zink quarry, in eastern Hillsboro, Ohio.

Fig. 8. *Poleumita prosseri* Foerste. A, lateral view; B, apical view; C, umbilical side. From Holophragma zone, in Zink quarry, in eastern Hillsboro, Ohio.

Fig. 9. *Poleumita paveyi* Foerste. A, lateral view of partially deformed specimen; B, apical view, oblique; C, umbilical view, partially distorted. From Holophragma zone, in Zink quarry, in eastern part of Hillsboro, Ohio.

Fig.10. *Diaphorostoma hillsboroensis* Foerste. A, lateral view, showing aperture; B, lateral view, from opposite side, of a second specimen; C, basal view, showing aperture; D, apical view. From Holophragma zone, in Zink quarry, in eastern part of Hillsboro, Ohio.

PLATE XVIII.

Fig. 1. *Stropheodonta (Brachyprion) newsomensis* Foerste. A, interior of pedicel valve; B, C, interiors of brachial valves. From Holophragma zone in Lilley member, in Zink quarry, in eastern Hillsboro, Ohio.

Fig. 2. *Encrinurus* cf. *ornatus* Hall and Whitfield. A, pygidium; B, obliquely lateral view of same; C, part of cephalon. From Holophragma zone at Zink quarry, in eastern Hillsboro, Ohio.

Fig. 3. *Phacops* (Portlockia) *mancus* Foerste. Cephalon. From Cedarville dolomite in eastern Mills quarry, southwest of Springfield, Ohio.

Fig. 4. *Dalmanites brevigladiolus* Foerste. A, B, C, fragments of pygidia; D, E, fragments of cranidia. From Holophragma zone, at Zink quarry, in eastern part of Hillsboro, Ohio.

Fig. 5. *Dalmanites* cf. *verrucosus* Hall. Cast of lower side of cephalon. From Cedarville dolomite, at Cedarville, Ohio.

Fig. 6. *Calymene* cf. *vogdesi* Foerste. Cranidium; see also Fig. 3 on Plate XIX. From Holophragma zone, at Zink quarry, in eastern part of Hillsboro, Ohio.

Fig. 7. *Proetus collinodosus* Foerste. A, cranidium; B, pygidium. From Holophragma zone, at Zink quarry, in eastern part of Hillsboro, Ohio.

PLATE XIX.

Fig. 1. *Calymene niagarensis* Hall. Profile of glabella and narrow anterior lip. Rochester shale; Lockport, New York.

Fig. 2. *Calymene breviceps* Raymond. Profile of glabella and narrow anterior lip; five lobes can be distinguished on each side of the glabella here figured. Waldron shale; Newsom, Tennessee.

Fig. 3. *Calymene* cf. *vogdesi* Foerste. Profile of glabella and broad flat anterior lip. In Holophragma zone in Lilley formation. Hillsboro, Ohio.

Fig. 4. *Calymene celebra* Raymond. Lip separated from anterior part of glabella by deep groove. Cedarville dolomite; Cedarville, Ohio.

Fig. 5. *Calymene vogdesi* Foerste. Broad lip separated from anterior part of glabella by a wide groove. Top of Brassfield formation, at Centerville, Ohio. Type specimen.

Fig. 6. *Proetus undulostriatus* (Hall). Sketch of type of *Cyphaspis hudsonica* Rudemann (Bull. New York State Mus., 49, 1901, p. 64, pl. 4, fig. 8), made by Dr. Ruedemann to indicate the present condition of the specimen. Snake Hill division of Trenton, on Green Island, near Albany, New York.

Fig. 7. *Ceraurinus* cf. *trentonensis* Barton. Part of cranidium. Kimmswick limestone, Sanders Branch, Ralls county, Missouri.

Fig. 8. *Pterygometopus achates* (Billings). Glabellar portion of the specimen figured by Clarke (Geol. Minnesota, 3, pt. 2, 1894, p. 727, fig. 44) as *Dalmanites achates* Billings, from the Trenton at Trenton Falls, New York. The glabellar furrows on the left side of this specimen were cleaned out and the enlarged drawing was prepared by Dr. Ruedemann.

Fig. 9. *Calymene whittakeri* Foerste. A, cranidium; b, same enrolled specimen, but placed so as to expose the pygidium, inverted. From the Collingwood formation, at Fields, half way between Collingwood and Meaford, on south side of Georgian Bay.

Fig. 10. *Proetus* cf. *undulostriatus* (Hall). A, cranidium; B, lateral profile. From the Strophomena vicina horizon, in the Trenton, northwest of Bridgeport, Kentucky.

Fig. 11. *Proetus parviusculus* Hall. A, cephalon; B, lateral profile. From Corryville member of Maysville formation, at Cincinnati, Ohio.

Fig. 12. *Proetus undulostriatus* (Hall). Sketch of original specimen identified as *Proetus undulostriatus* by Dr. Ruedemann (Bull. New York State Mus., 162, 1912, p. 117, fig. 3) from the Snake Hill member of the Trenton, at Snake Hill, New York.

Fig. 13. *Proetus princeps* Savage. A, an attempted restoration of the cranidium figured by Savage. B, pygidium referred to this species by Savage, in his collection. From the Girardeau limestone, near Thebes, Illinois.

Fig. 14. *Proetus determinatus* Foerste. A, B, cranidia; B, from the Savage collection, but not a figured specimen. C, cephalon, showing traces of glabellar furrows, but these traces are much accentuated in the figure. D, pygidium. From the Edgewood limestone, at Thebes, Illinois.

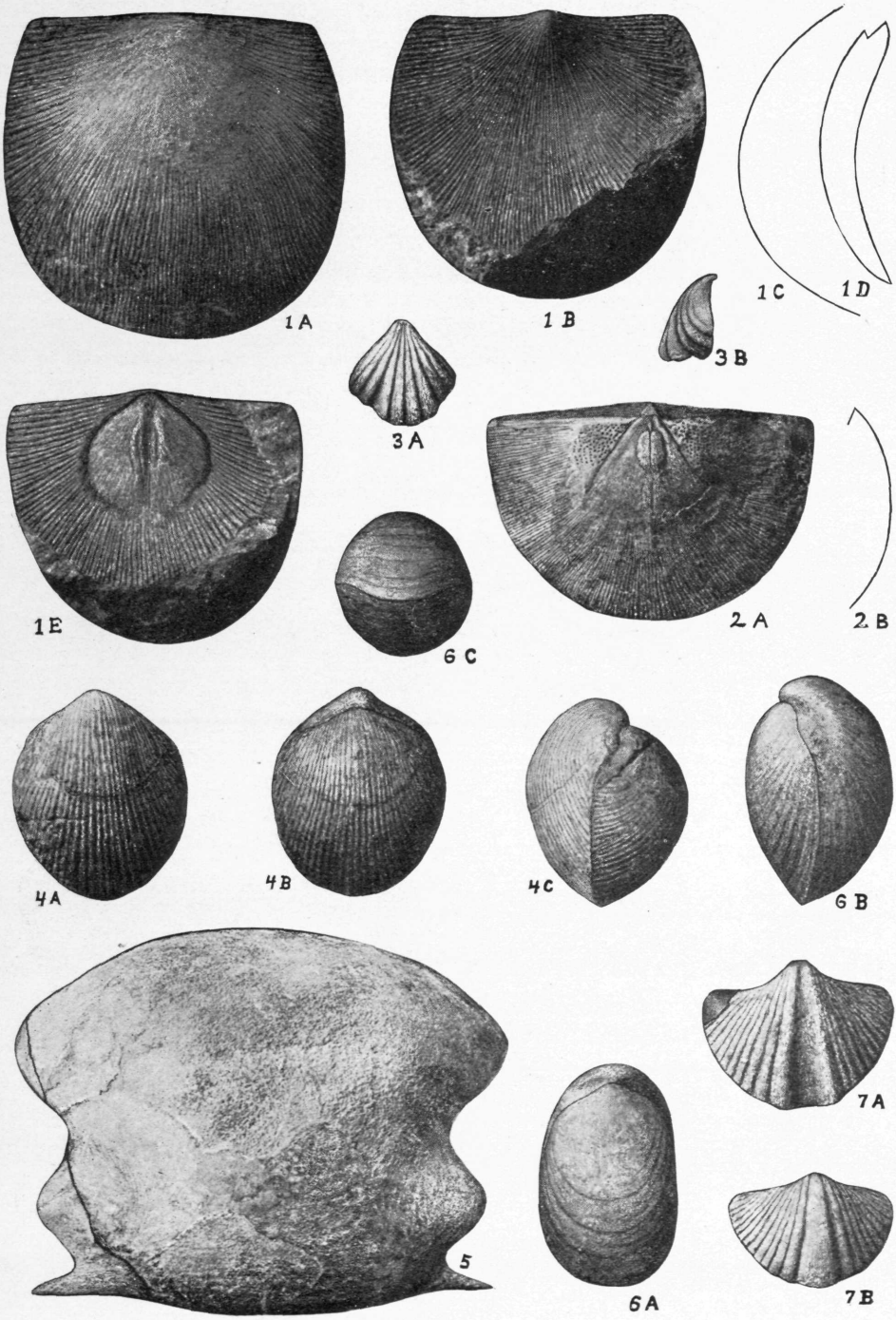
Fig. 15. *Platycoryphe dubia* (Savage). A, attempted restoration of cranidium (type) figured by Savage. B, pygidium (type) figured by Savage. (*Calymene dubia* Savage, Bull. Geol. Surv. Illinois, 23, 1913, p. 60, pl. 2, figs. 8, 9). From the Girardeau limestone, in Alexander county, Illinois.

Fig. 16. *Platycoryphe platycephala* Foerste. A, pygidium (type) seen from above; B, obliquely lateral view of same. (=*Calymene platycephala*). From the Saltillo member of the Trenton, at Clifton, Tennessee.

Fig. 17. *Pterygometopus carleyi* (Meek). Cephalon, from Fairmount member of Maysville formation, at Cincinnati, Ohio.

Fig. 18. *Pterygometopus rogersensis* Foerste. A, Cast of under side of cephalon slightly restored; B, free cheek, with occular surface attached. A, *Dalmanites achates*, five miles north of Rogers Gap, Kentucky, along the railroad, (Jour. Cincinnati Soc. Nat. Hist. 21, 1914, pl. 1, fig. 18), from Rogers Gap member of Cynthiana formation. B, from bridge 54, west of Million tunnel.

Fig. 19. *Pterygometopus confluens* Foerste. Cranidium. From Tyrone member of Black River formation, at High Bridge, Kentucky.



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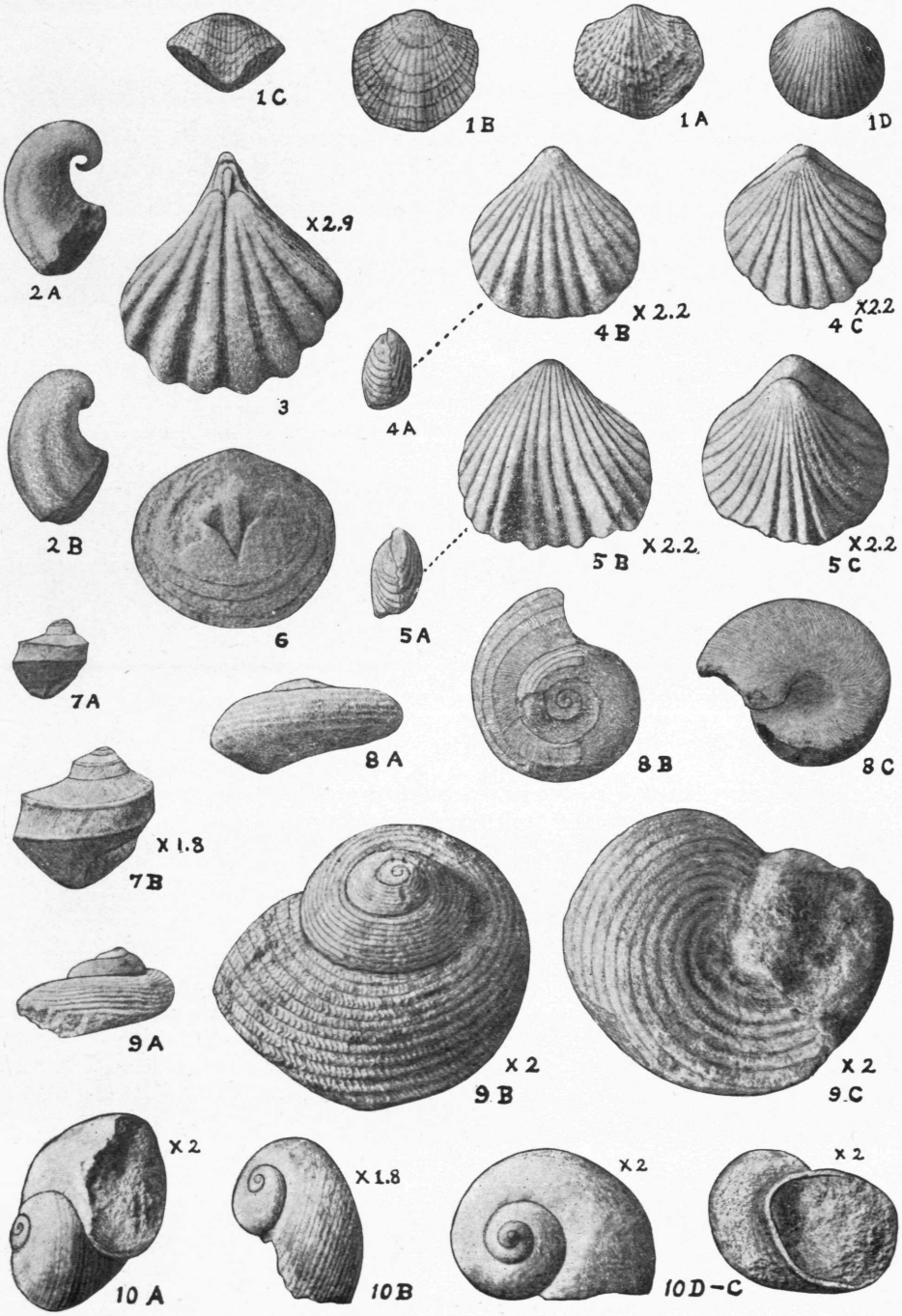

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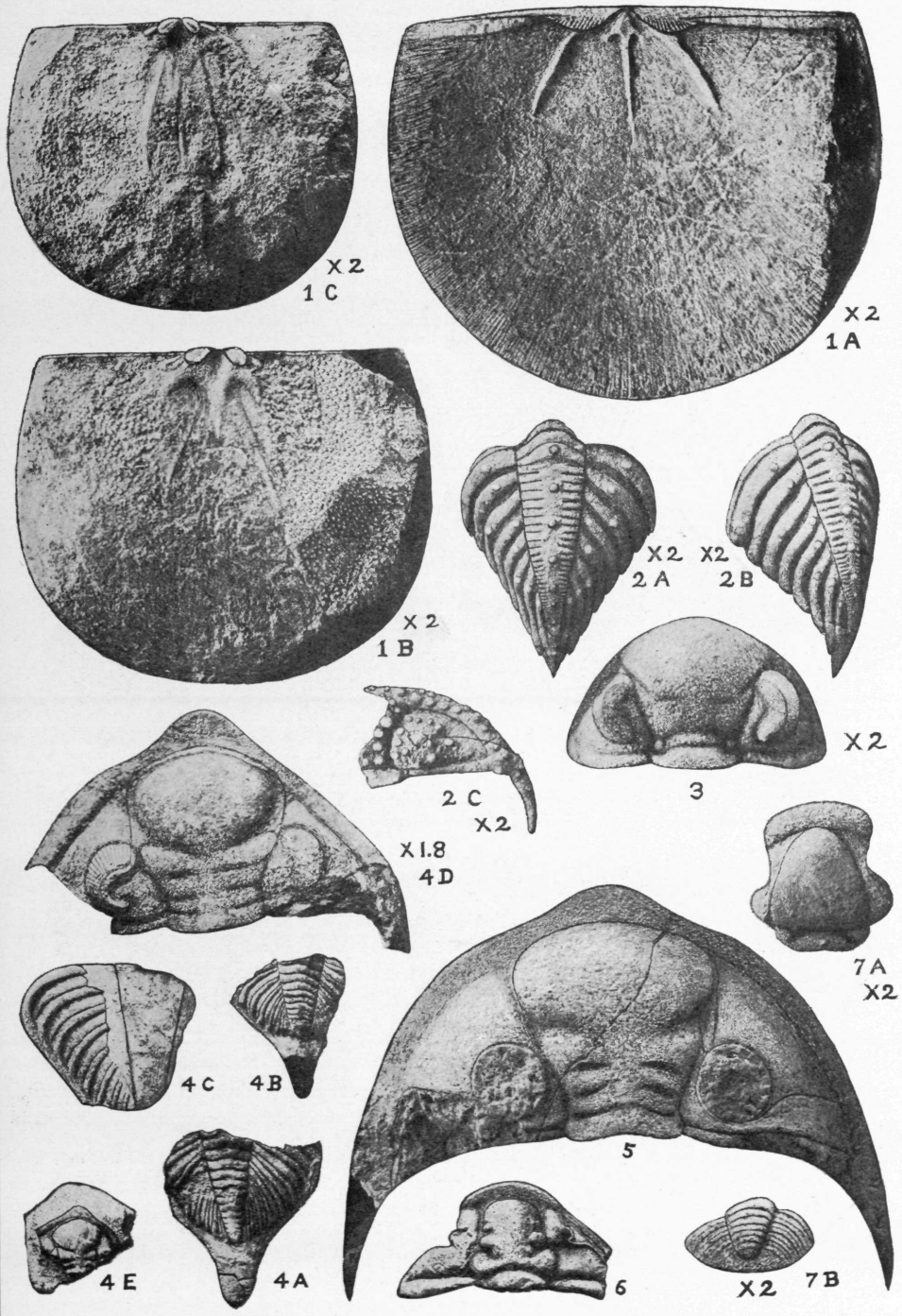

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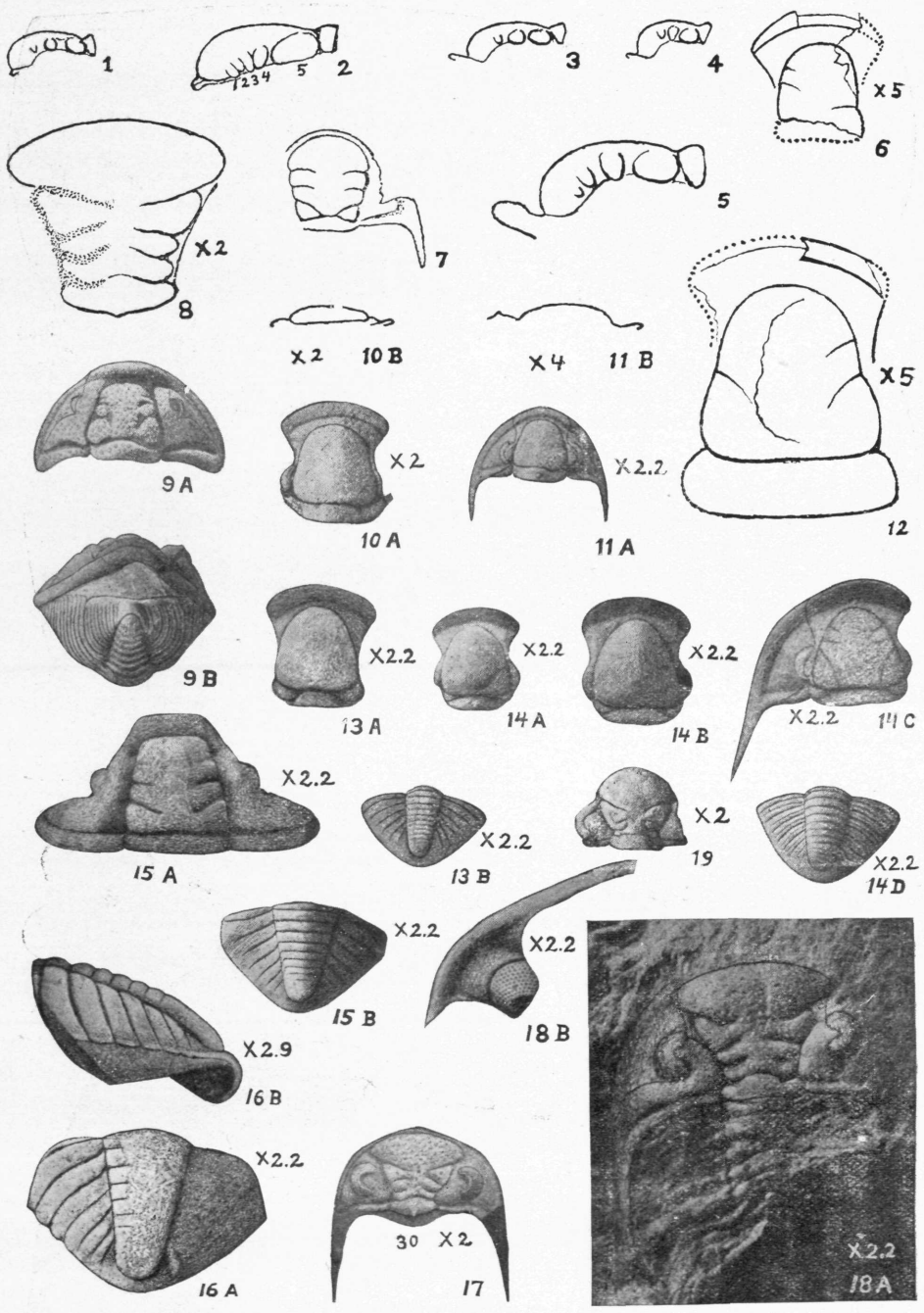

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